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TECHNICAL
REPORT

The Future of Air Force Motion Imagery Exploitation

Lessons from the Commercial World

Lance Menthe, Amado Cordova, Carl Rhodes,
Rachel Costello, Jeffrey Sullivan

Prepared for the United States Air Force

Approved for public release; distribution unlimited

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Preface

Dramatic changes in the security environment in the past two decades have led to a greatly increased demand for U.S. Air Force intelligence, surveillance, and reconnaissance (ISR) capabilities. Today, the Air Force must provide ISR to a growing set of missions, from the global fight against terrorist organizations to humanitarian relief efforts around the globe, while remaining postured to support major combat operations should the need arise.

To meet these requirements, the Air Force is currently undertaking unprecedented measures to expand and enhance its ISR capabilities. Particular urgency has been attached to cultivating its fleet of sophisticated remotely piloted aircraft (RPAs) to support current operations in Afghanistan and Iraq. Equally critical to these efforts, however, is the Air Force's extensive processing, exploitation, and dissemination (PED) force, which is essential to convert the raw data collected into usable intelligence and deliver it to the warfighter. It is therefore imperative to assess the size and mix of the Air Force's PED force to ensure that the ability to conduct all necessary PED within required timelines keeps pace with the increases in the amount and type of information collected.

In this report, part of a fiscal year 2009–2010 study "Sizing the U.S. Air Force ISR Force to Meet Future Challenges," we addressed the particular challenges associated with the exploitation of motion imagery within the Air Force Distributed Common Ground System (DCGS). Motion imagery collections from full-motion video sensors on RPAs have risen rapidly to the point at which they now consume the largest share of Air Force DCGS resources, and new wide-area motion imagery sensors now being deployed have the potential to increase the amount of raw data collected by an order of magnitude. The information explosion resulting from these vast amounts of motion imagery threatens to overwhelm Air Force intelligence analysts.

Two reports emerged from this study, representing two distinct approaches to meet these challenges. One approach, described in this report, was inspired by an examination of related practices in the commercial world. It consists of implementing certain process changes and adopting a new organizational construct to improve the effectiveness of Air Force intelligence analysts while confronting the reality of limited resources. A second approach, the subject of the companion report, consists of adopting new tools and technologies to alleviate the workload and otherwise to improve the efficiency of Air Force PED processes.[1] Although the recom-

[1] Amado Cordova, Lance Menthe, Lindsay D. Millard, Carl Rhodes, and Jeffrey Sullivan, *Emerging Technologies for Intelligence Analysts: Recommendations for the Air Force DCGS Enterprise*, Santa Monica, Calif.: RAND Corporation, unpublished draft.

mendations that arise from these take rather different forms, we wish to emphasize that they are fully compatible and that both approaches should be pursued.

Findings and recommendations from this work are also relevant to other organizations that conduct intelligence analysis, notably the Air Force's counterpart services—Army, Navy, and Marine Corps—as well as members of the national intelligence community, such as the National Geospatial-Intelligence Agency.

This report is part of an ongoing series of RAND Project AIR FORCE studies of ISR and ISR-related work. Previous studies have looked at ISR planning and execution and the ISR capabilities of RPAs and other assets:

- *A Strategies-to-Tasks Framework for Planning and Executing Intelligence, Surveillance, and Reconnaissance (ISR) Operations*, Carl Rhodes, Jeff Hagen, and Mark Westergren, Santa Monica, Calif.: RAND Corporation, TR-434-AF, 2007.
- *Methodology for Improving the Planning, Execution, and Assessment of Intelligence, Surveillance, and Reconnaissance Operations*, Sherrill Lingel, Carl Rhodes, Amado Cordova, Jeff Hagen, Joel Kvitky, and Lance Menthe, Santa Monica, Calif.: RAND Corporation, TR-459-AF, 2008.

Current studies examine more specifically the human analyst–machine relationship and the potential automation of ISR PED processes.

The research reported here was sponsored by the Deputy Chief of Staff for ISR, Headquarters U.S. Air Force; the Director of ISR Strategy, Integration, and Doctrine; the Assistant Deputy Chief of Staff of ISR; the Director of ISR Capabilities; and the Technical Advisor for ISR Capabilities and Integration and conducted within the Force Modernization and Employment Program of RAND Project AIR FORCE.

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Summary

Motion imagery has become an increasingly important Air Force intelligence, surveillance, and reconnaissance (ISR) capability in recent years. When the operations in Afghanistan and Iraq began, only a handful of Air Force assets capable of delivering motion imagery were deployed in theater; now they number in the hundreds. The Air Force has also begun to deploy wide-area motion imagery sensors with the potential to collect far more motion imagery.

The dramatic increase in motion imagery collections presents a challenge to the Air Force Distributed Common Ground System (DCGS), the global federated enterprise—and formal weapon system—charged with conducting the vast majority of the processing, exploitation, and dissemination (PED) processes required to convert raw motion imagery into intelligence useful to the warfighter. Yet, if properly managed, this new capability also offers the opportunity to achieve more-coordinated, more-agile Air Force ISR operations than ever before.

Because the collection and analysis of motion imagery on such a large scale are relatively new capabilities for the Air Force, we sought insights from two established commercial industries that routinely conduct video surveillance: closed-circuit television and reality television production. In this report, we examine the parallels between these industries' practices and those of the Air Force, and, from this analysis, we arrive at four recommendations.

First, Air Force motion imagery exploitation crews should adopt the television production "control room" format. The part of the operations floor dedicated to motion imagery PED should be organized to face a common operational picture display that allows the analysts to see all relevant motion imagery. Any other geolocated intelligence that is available and can provide context should also be displayed.

Second, the Air Force should build and maintain a unified multimedia database to store motion imagery, as well as still imagery. Such a database would facilitate subsequent analysis and correlation of data by the Air Force and others. The Air Force should consider the feasibility of adapting existing commercial products to this task.

Third, the Air Force should streamline communications practices within the Air Force DCGS and between the Air Force DCGS and other partners. A common lexicon for text-based communications would be a valuable addition to Air Force doctrine. Providing imagery analysts the option of using headsets with speech-to-text capabilities could also facilitate their participation in chat rooms. Motion imagery PED crews should also move toward a policy of maintaining a single point of contact for each unit they support.

Fourth, looking to the future, the Air Force should move to adopt a new "area-centric" organizational construct for motion imagery PED. This proposed organizational construct reframes the Air Force PED mission, shifting the focus from conducting PED separately for each platform to coordinating PED for all platforms in an area of operations. The area-centric

construct is designed to capitalize on cross-cueing opportunities and to assist PED crews in supporting multiple units. It also provides for a "PED triage" mechanism to allow the Air Force to apply its resources selectively as the need arises.

These recommendations stand independently of one another. The first three are intended primarily to address the needs of current and near-term operations, and, as such, we recommend implementation as soon as possible. They should also facilitate the ongoing shift toward operation in multiple intelligence domains. The final recommendation is meant to meet the longer-term needs of the Air Force DCGS and entails a larger change in operations. As prevailing conditions in the ISR enterprise shift inexorably from scarcity to plenty, area-centric organization offers a better way for the Air Force DCGS to prepare to meet that future.

Acknowledgments

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Abbreviations

A2	Intelligence Directorate
AD	assistant director
AFB	Air Force base
ARGUS	Autonomous Real-Time Ground Ubiquitous Surveillance
CAN	correlation analyst
CAP	combat air patrol
CCTV	closed-circuit television
CML	crew manning letter
CMS	crew manning standard
COCOM	combatant command
COP	common operational picture
DCGS	Distributed Common Ground System
DGS	deployable ground station
FMV	full-motion video
FTP	file transfer protocol
FY	fiscal year
GMTI	ground moving target indicator
IA	imagery analyst
IED	improvised explosive device
IMINT	imagery intelligence
IMS	imagery mission supervisor
IMS-M	imagery mission supervisor–management
IMS-O	imagery mission supervisor–operations

INT	intelligence domain
IRC	Internet relay chat
IRE	imagery report editor
IS	intelligence squadron
ISR	intelligence, surveillance, and reconnaissance
ISRMC	intelligence, surveillance, and reconnaissance mission commander
LRE	launch and recovery element
MCE	mission control element
MOC	mission operations commander
MQ-1	Predator
MQ-9	Reaper
MTO	mission type order
MTS	Multi-Spectral Targeting System
nmi	nautical mile
PAF	RAND Project AIR FORCE
PED	processing, exploitation, and dissemination
RC-135V/W	Rivet Joint
RPA	remotely piloted aircraft
SIGINT	signals intelligence
SOF	special operations forces
TACOM	tactical communicator
WAMI	wide-area motion imagery

CHAPTER ONE

Introduction: The Rise of Motion Imagery

Taken as a whole, intelligence, surveillance, and reconnaissance (ISR) encompasses the set of processes that aims to provide accurate, relevant, and timely information to the decisionmaker.[1] In previous conflicts, particularly in major combat operations, ISR was employed primarily to obtain the high-quality information required to strike a target. The current wars in Iraq and Afghanistan, characterized by extended, low-intensity operations, have demonstrated the value of ISR in a broader range of activities, from identifying improvised explosive device (IED) emplacement to understanding "patterns of life" of civilian populations. As a consequence, over the past few years, the demand for ISR has skyrocketed.

The Air Force provides ISR capabilities to the warfighter in several forms, including collection assets—the platforms, sensors, and personnel required to operate them—and an extensive processing, exploitation, and dissemination (PED) architecture.[2] Broadly speaking, *processing* refers to the conversion of collected information into forms suitable for the production of intelligence, *exploitation* to the analysis of this information and the production of intelligence, and *dissemination* to the delivery of this intelligence to the end users.[3] Air Force PED spans many intelligence domains (INTs), including imagery intelligence (IMINT),[4] signals intelligence (SIGINT), and measurement and signature intelligence. Although its contributions are more difficult to quantify than those of collection assets, PED is an equally critical aspect of ISR. In response to the growing demands, the Air Force therefore has made considerable investments in both of these areas.

Several current Air Force collection assets, which first demonstrated their value during the Cold War, continue in service, including the U-2 Dragon Lady and the Rivet Joint (RC-

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[1] Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms*, as amended through April 2010, defines ISR somewhat more abstractly as an "activity that synchronizes and integrates the planning and operation of sensors, assets, and processing, exploitation, and dissemination systems in direct support of current and future operations" (U.S. Joint Chiefs of Staff, Joint Doctrine Division, *Department of Defense Dictionary of Military and Associated Terms*, Joint Publication 1-02, as amended through April 2010).

[2] Tasking processes and the global communications architecture are other important ISR capabilities, but they lie outside the scope of this report.

[3] See U.S. Joint Chiefs of Staff, *Joint and National Intelligence Support to Military Operations*, Joint Publication 2-01, Appendix II, October 7, 2004. Note that "processing and exploitation" is defined therein as a single concept, not as two separate terms.

[4] Although *IMINT* remains the most popular term in common parlance, *geospatial intelligence* is increasingly used in place of *IMINT*. Geospatial intelligence is a broader intelligence discipline that encompasses much of IMINT and a host of other nonimaging spatial data, such as radar moving target indicators. See U.S. Joint Chiefs of Staff, *Geospatial Intelligence to Support Joint Operations*, Joint Publication 2-03, March 22, 2007b. Note that, in this report, we use the term *IMINT* to refer to still imagery only; for convenience, we implicitly treat motion imagery as a separate INT.

135V/W). Others, such as the Joint Surveillance Target Attack Radar System, debuted in the early 1990s and were instrumental in the success of coalition forces during the first Gulf War. The newest family of Air Force collection assets is remotely piloted aircraft (RPA),[5] including the Predator (MQ-1) and the Reaper (MQ-9).[6]

RPAs are unique Air Force assets in that, as their name implies, they are operated at a distance. Satellite-based telecommunications links, with associated wireless and fiber optic networks, permit these aircraft to be flown by pilots physically located on the opposite side of the world.[7] Currently, Air Force Predators and Reapers are piloted by reconnaissance and attack squadrons stationed at Creech Air Force Base (AFB) in Nevada, as well as from various other sites throughout the United States. RPA sensors are also controlled remotely. Sensor operators, typically colocated with the pilot at the RPA ground control station, direct the RPA's sensors in accordance with the requirements of the "customer"—usually the commander of the ground unit that they are supporting. Together, the pilot and sensor operators form the mission control element (MCE) for the RPA. Meanwhile, a separate launch and recovery element (LRE) maintains the aircraft in theater. The Air Force refers to this division as *remote split operations*.

Among the most sought-after of the Air Force's ISR capabilities—one that has gained great popularity among commanders in current operations—is motion imagery from these medium-altitude RPAs.[8] When Operations Enduring Freedom and Iraqi Freedom began, only a handful of platforms capable of providing motion imagery were deployed in theater; now they number in the hundreds. More than 10,000 hours of motion imagery are now collected every month in Afghanistan and Iraq combined.[9]

Motion Imagery Collection

The Air Force's most established motion imagery collection asset is the Multi-Spectral Targeting System (MTS), deployed on the Predator and Reaper.[10] This system offers high-resolution, narrow-field-of-view (so-called soda-straw) daytime television cameras that provide FMV in color at 30 frames per second and day-and-night television cameras that provide similar performance at infrared wavelengths. The system currently delivers motion imagery in standard resolution, although high-definition output will soon be available.

In 2009, the Air Force also began to fly manned MC-12W Liberty aircraft in theater, equipped with L-3 Westar's MX-15i sensor turret, which provides motion imagery comparable

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5 Also referred to as *remotely piloted vehicles*, *unmanned aerial vehicles*, *unmanned aircraft systems*, and prosaically in the popular press as *drones*.

6 Formerly designated Predator B (renamed in 2006).

7 Air Force MQ-1 and MQ-9 platforms do not have automatic takeoff and landing capabilities at this time, however; takeoff and landing must be accomplished by a qualified pilot with line of sight to the aircraft.

8 A motion imagery system is "[a]ny imaging system that collects at a rate of one frame per second (1 Hz) or faster, over a common field of regard." See U.S. Department of Defense/Intelligence Community/National System for Geospatial Intelligence Motion Imagery Standards Board, *Motion Imagery Standards Profile Version 5.4*, December 3, 2009. Note, however, that full-motion video (FMV) is reserved for a more rapid frame rate, as described later.

9 Christopher Drew, "Drones Are Weapons of Choice in Fighting Qaeda," *New York Times*, March 16, 2009.

10 MTS-A, Predator AN/AAS-52; MTS-B, Reaper AN/DAS-1.

to that of the Predator and Reaper.[11] And, as of 2011, the Air Force has begun to deploy much-anticipated wide-area motion imagery (WAMI)[12] sensors on the Reaper to provide motion imagery over an area much larger than what is offered by the narrow-field-of-view sensors.[13] WAMI sensors operate at a slower frame rate, however: They do not yet offer true FMV.[14]

The first Air Force WAMI sensor to be deployed is Gorgon Stare, a quick-reaction capability developed for the Reaper.[15] Although the coverage area of narrow-field-of-view FMV sensors at equivalent resolution is measured in tens or hundreds of square meters, Gorgon Stare provides coverage of several square kilometers at once.[16] (The frame rate, however, is only 2 frames per second.) The next developmental increment of Air Force WAMI systems, scheduled as of this writing for initial deployment by the end of fiscal year (FY) 2011, incorporates the Defense Advanced Research Projects Agency's Autonomous Real-Time Ground Ubiquitous Surveillance (ARGUS) system.[17] Built around a 1.8-gigapixel camera, ARGUS has the potential to provide simultaneous coverage of more than 100 square kilometers.[18] Although ARGUS is expected to yield a higher frame rate than Gorgon Stare, it will still fall short of FMV.[19]

Motion Imagery Processing, Exploitation, and Dissemination

The same "power of the network" that enables remote split operations for RPA operations also permits the Air Force to conduct PED from afar, via the global Air Force Distributed Common Ground System (DCGS).[20] The Air Force DCGS is an ISR weapon system managed

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[11] Later versions of the platform will carry somewhat more-advanced versions of this sensor.

[12] This capability is also referred to in different contexts as *wide-area airborne surveillance*, *wide-area persistent surveillance*, *wide-area large format*, and *large-volume streaming data*.

[13] As currently planned, Reapers enabled with Gorgon Stare will also continue to carry the original MTS.

[14] In this report, we use *FMV* to refer to motion imagery at 24 frames per second or higher. This is generally considered the minimum frame rate required to appear fluid to the human eye. The Motion Imagery Standards Board notes that, "Historically . . . FMV has been that subset of motion imagery at television-like frame rates (24–60 Hz)" (Geospatial Intelligence Standards Working Group, Motion Imagery Standards Board, "Frequently Asked Questions [FAQ]," updated February 9, 2011).

[15] The quick-reaction capability process is an acquisition process designed to meet an urgent operational need. See Secretary of the Air Force, Quick Reaction Capability Process, Air Force Instruction 63-114, January 4, 2011.

[16] Michael Hoffman, "Gorgon's Gaze Set for Fall in Afghanistan," *Air Force Times*, June 13, 2010.

[17] ARGUS comes in two flavors: ARGUS-IS, the imaging system operating at visible wavelengths, and ARGUS-IR, the day-and-night infrared system. The development of ARGUS-IS leads that of ARGUS-IR.

[18] William Matthews, "One Sensor to Do the Work of Many," *Defense News*, March 1, 2010; Lt Gen David Deptula, "Air Force ISR in a Changing World," in *Proceedings of the Royal Australian Air Force Air Power Conference*, Canberra, Australia, March 30, 2010.

[19] Estimates for ARGUS's final capability range from 5 to 15 frames per second in various reports. See, for example, Defense Advanced Research Projects Agency, *Autonomous Real-Time Ground Ubiquitous Surveillance–Infrared (ARGUS-IR) System*, Solicitation DARPA-BAA-10-02, December 14, 2009.

[20] The Air Force DCGS weapon system is formally designated AN/GSQ-272 SENTINEL. The Army and Navy operate other systems, named the Distributed Common Ground System–Army and the Distributed Common Ground System–Navy, respectively; for more about "power of the network" in the Air Force, see Maj Gen Craig Koziol, *Proceedings of Infotech 2008 Conference*, Dayton, Ohio, October 22, 2008.

by the 480th ISR Wing headquartered at Langley AFB, Virginia. It is the Air Force's primary warfighting PED architecture and conducts the vast majority of Air Force motion imagery PED. It is a federated system, meaning that its dozen or so deployable ground station (DGS) sites around the world—including active duty, Air National Guard, and reserve units—are not intended to function independently but to work together as one enterprise, along with distributed mission sites and federated partners.[21]

As a practical matter, PED tasks are generally divided among the DGS sites in advance by means of a PED tasking order, but, in principle, PED crews can be split across DGS sites, and it is common for DGS sites to exchange or assume new PED tasks as circumstances demand. Time zone considerations, technical difficulties, aircraft maintenance issues, and shifting weather conditions lead to almost hourly fluctuations in PED activity at DGS sites.

Growing Demand

Air Force Predators and Reapers are currently deployed in combat air patrols (CAPs). In this context, a CAP denotes the capability to provide persistent surveillance—24 hours per day, seven days per week—over a given region of interest or during a particular mission.[22] The requirement of 24/7 coverage implies that several aircraft are needed to maintain a single CAP. Because of this common deployment pattern for motion imagery collection assets, CAPs—not hours of coverage or number of platforms—have become the common currency used by Air Force planners to measure the demand for motion imagery and to allocate associated resources.[23]

The resources required to operate a single Predator or Reaper CAP and to provide the warfighter with the intelligence derived from its narrow-field-of-view FMV sensor are substantial. A maximal crew of 192 airmen can be associated with a single Predator or Reaper CAP, including 30 intelligence analysts dedicated to the exploitation of motion imagery alone.[24] However, where crews are colocated, certain personnel are shared, leading to significant savings. Even with manpower savings from such economies of scale, however, total crew positions associated with RPAs already run into the thousands.[25] And these figures do not yet account for the impact of Gorgon Stare and future WAMI sensors. The greatest challenge in deploying additional "unmanned" ISR capabilities could prove, ironically, to be manpower.

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21 Including coalition partners.

22 Some Air Force organizations use *orbit* to refer to this capability and use *CAP* to refer to the programmatic element of four aircraft commonly used to provide it. This distinction becomes significant when maintaining the capability requires more than the programmatically allotted number of aircraft—as when the base is far from the target and thus time on station is reduced.

23 As we discuss in Chapter Three, this formulation could require some rethinking when WAMI sensors and other multiple-camera arrangements enable a single platform to support several customers, and vice versa.

24 These are maximal figures that incorporate all manpower factors accounting for leave, illness, and the multiple shifts required to sustain 24/7 operations.

25 For FY 2011, the Air Force A2CU, the RPA Task Force, estimates that approximately 4,750 PED personnel are dedicated to Air Force RPAs, in addition to all other associated personnel (RPA Task Force, "RPA Fast Facts," Headquarters U.S. Air Force, RPA Task Force, January 1, 2011).

Following is a list of Air Force personnel required to support one Predator or Reaper CAP:[26]

- MCE (49 total)[27]
  – ten pilots
  – ten sensor operators
  – eight maintenance
  – five mission coordinators
  – two leadership
  – 14 administrative/overhead
- LRE (59 total)[28]
  – three pilots
  – three sensor operators
  – 53 maintenance
- PED (84 total)
  – 30 FMV analysts
  – 23 SIGINT analysts
  – 14 maintenance
  – 17 miscellaneous backshop personnel.[29]

The demand for Predator and Reaper motion imagery has grown quickly over the past several years, and the appetite of ground commanders in this regard shows no signs of subsiding (see Figure 1.1). Until recently, the Air Force's goal was to achieve a stable number of 50 CAPs by FY 2013, but the recent Quadrennial Defense Review raised the bar to 65.

Because the motion imagery systems on the Predator and Reaper provide only a single, narrow field of view, which, for lack of a better term, we call a *motion imagery spot*, there is currently a convenient one-to-one correspondence between motion imagery spots and CAPs.[30] However, Gorgon Stare will provide ten or more "video chips" (or "chip-outs") of delimited sub-areas, each approximately equivalent in field of view to a single Predator or Reaper motion imagery spot, and ARGUS could provide 65. Figure 1.2 illustrates the substantial increase in total motion imagery spot equivalents expected over the next several years. By 2015, the number of motion imagery spot equivalents, currently less than 60, could increase to nearly 4,000. Clearly, the growth in CAPs and advent of WAMI sensors pose special challenges for Air Force PED.

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[26] RPA Task Force, 2011; Deptula, 2010. These are maximal figures that incorporate all manpower factors accounting for leave, illness, and the multiple shifts required to sustain 24/7 operations.

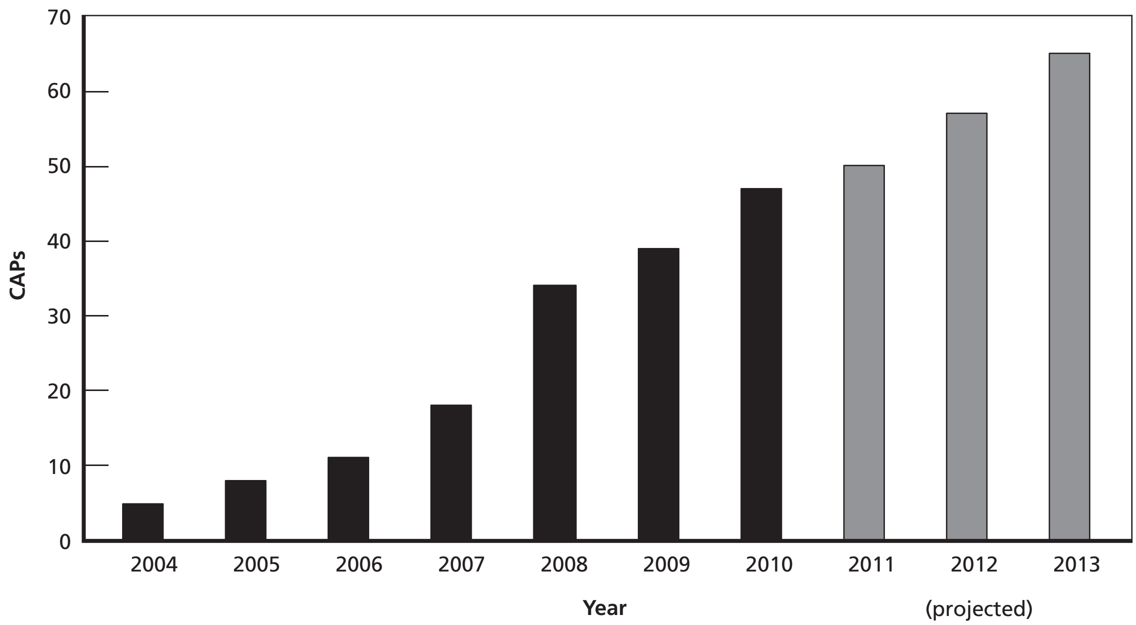
[27] These are steady-state numbers. When the force is stretched for a surge, as is common in current operations, the numbers of pilots and sensor operators in the MCE can each be reduced from ten to seven.

[28] As indicated earlier, LRE personnel figures are smaller for additional CAPs flown from the same airbase. LRE maintenance personnel can be reduced by 50 percent or more for additional CAPs (see Deptula, 2010). In principle, LRE pilots for additional CAPs can also be fewer: So long as only one RPA is launched or landed within a certain time window, the same LRE could launch and land all of the RPAs flown from the same airbase—although obviously the workload would be considerably more stressing.

[29] Where additional PED crews are colocated, the miscellaneous backshop personnel who support them can be shared.

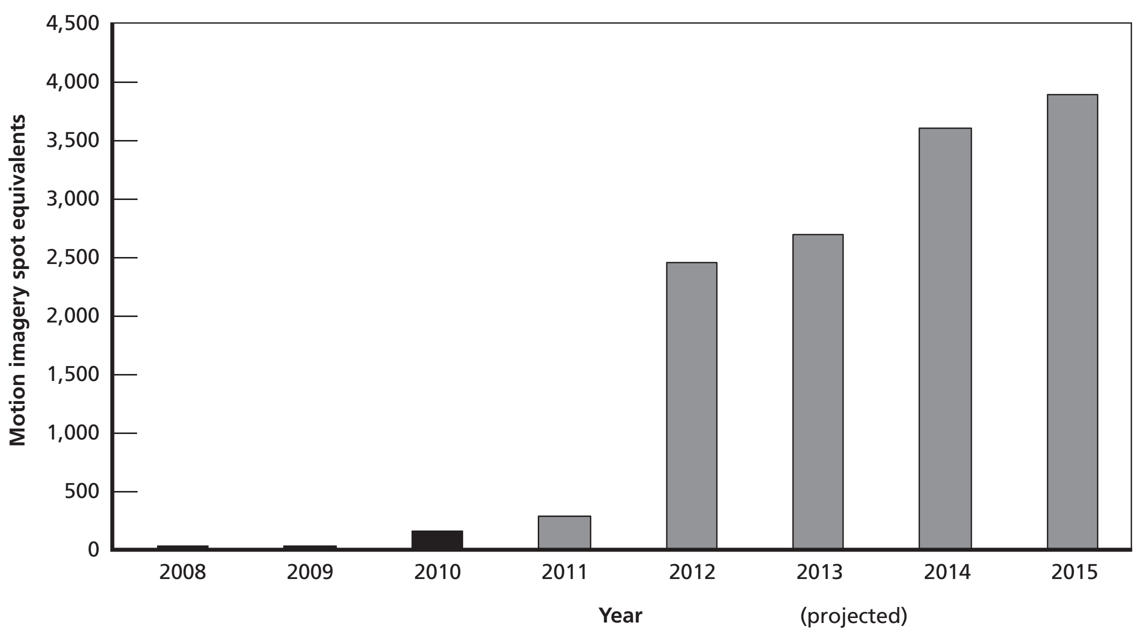
[30] In this report, we use the term *motion imagery spot* to refer to a contiguous area of continuous coverage, equivalent to the field of view of a single soda-straw camera.

Figure 1.1
Growth in Predator and Reaper Combat Air Patrols



SOURCES: Deptula, 2010; RPA Task Force, 2011.
NOTE: Current as of January 1, 2011.
RAND *TR1133-1.1*

Figure 1.2
Growth in Predator and Reaper Motion Imagery Spot Equivalents from Full-Motion Video and Wide-Area Motion Imagery Sensors



SOURCE: Deptula, 2010.
RAND *TR1133-1.2*

One note of caution: The advertised approximate equivalence of motion imagery spots is useful for discussing certain, but not all, PED processes in the same breath. The comparison between narrow-field-of-view FMV systems and WAMI systems is much more complex. It should also be noted that present plans call for WAMI video chips and subviews, but not the full WAMI image, to be disseminated to the Air Force DCGS in near real time.[31] The bandwidth required to transmit WAMI imagery is considerable, and the images themselves are too large to fit on a single video screen at full resolution.[32] The Remote Optical Video Enhanced Receiver terminals with which ground forces are equipped can receive these video chips.[33] Enterprise-wide distribution of the full WAMI image in near real time is a future capability discussed in this report.

Meeting the Demand

The Air Force allocates PED manpower in the same way that it assigns aircrews: a fixed number of people per CAP, the numbers varying by platform type.[34] We refer to this organizational construct as the *platform-centric* approach. There is somewhat more flexibility in this approach at DGS–Special Operations Forces (SOF), which formally aligns a PED crew with a supported unit rather than a specific platform. In practice, however, supported units are typically assigned exclusive use of a single platform, so the difference is nominal—and, in any event, PED crew staffing requirements are still calculated in terms of the number and type of platforms. Given that each platform also currently has one narrow-field-of-view FMV sensor, the platform-centric organizational construct translates to assigning each motion imagery spot to a standard motion imagery exploitation crew.[35]

The standard motion imagery exploitation crew consists of the following: at least one "eyes-on" imagery analyst (IA),[36] i.e., an analyst assigned to watch the motion imagery spot continuously; at least one analyst in charge of communicating with the pilot, the sensor operator, and the supported unit; and at least one supervisor.[37] Although official crew manning standards (CMSs) call for a total of seven individuals (chiefly, additional IAs), the actual number of positions, especially at the larger DGS sites, which exploit the motion imagery from several

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[31] We use the phrase *near real time* to characterize PED processes that entail only a few seconds of delay, usually due to transmission and processing times.

[32] Davi M. D'Agostino, director, Defense Capabilities and Management, *Intelligence, Surveillance, and Reconnaissance: Overarching Guidance Is Needed to Advance Information Sharing—Testimony Before the Subcommittees on Air and Land Forces and Seapower and Expeditionary Forces, Committee on Armed Services, House of Representatives*, Washington, D.C.: U.S. Government Accountability Office, GAO-10-500T, March 17, 2010.

[33] Brig Gen VeraLinn Jamieson, untitled entry, *C4ISR Journal*, October 1, 2009.

[34] The crew is usually assigned to the platform flying the CAP rather than to the CAP itself.

[35] This is usually called an *FMV crew*. We use the broader term *motion imagery* in anticipation of exploiting less-than-full-motion imagery, such as that currently offered by WAMI sensors.

[36] Some sources now repurpose the abbreviation *IA* to stand for *geospatial intelligence analyst*.

[37] As a historical note, the Air Force originally envisioned a Predator exploitation cell to include a "shift supervisor and up to seven imagery analysts [including] one voice narrator, one database operator, and up to five exploiters per shift." The number of IAs has been reduced, but the basic format is unchanged. See Air Combat Command, *Concept of Operations for Endurance Unmanned Aerial Vehicles*, Version 2, December 3, 1996, Section 5.7.11.

platforms simultaneously, is more typically the minimum of three or four personnel as indicated by DGS crew manning letters (CMLs).[38] Actual PED manning is negotiated regularly between the Air Force ISR Agency and the director of operations at each DGS site. The numbers vary from site to site and fluctuate over time, depending on such factors as the number of supported missions and the availability of personnel.

The Air Force has not yet determined, however, how to assign Air Force DCGS personnel to provide PED for all of the WAMI video chips, nor for the WAMI image as a whole.[39] Because it is currently impractical to transmit the entire WAMI image in real time to the Air Force DCGS, current plans involve forward-based ISR exploitation cells modeled after those currently deployed in theater to support MC-12W Liberty aircraft. Regardless of where the PED is conducted, however, the fundamental question remains: If a WAMI video chip is approximately equivalent in coverage area to a narrow-field-of-view FMV sensor, are the PED requirements also the same? And if not, how should they be determined?

It is clear to all that imposing PED requirements on WAMI video chips that are identical to those for current narrow-field-of-view FMV sensors would lead to an unsustainable rate of growth in PED manpower. Naïvely multiplying the motion imagery crew size by the number of motion imagery spot equivalents, we see that, by 2015, the Air Force could, in theory, require up to 117,000 personnel dedicated to motion imagery exploitation alone—one-third of the active-duty Air Force.[40]

There are several ways in which that fictitious "scare number" can be reduced. If the CML minimum crew size is used instead of the CMS requirements—a more accurate reflection of current practice—the total personnel required would be approximately halved, although clearly this would still leave an untenable number. More modest savings are also possible by stretching supervisors to oversee several crews.[41] Reducing crew size by consolidating analyst positions is another option; however, as we discuss in Chapter Two, such consolidation carries the risk of reduced effectiveness.

More promising is the potential of future automatic target recognition technologies to assist analysts by maintaining nonhuman "eyes-on" motion imagery and cueing human analysts to observe only those segments or chips deemed of interest. This would alleviate much of the current workload of Air Force PED analysts, who currently must observe all of the motion imagery collected. (The potential for such automation is discussed in the companion report.) We discuss in Chapter Three a new PED organizational construct that, among other things, paves the way for the future insertion of automatic target recognition technologies when they are available. But such technologies are not yet ready to assume this burden, and the requirements of such systems in terms of speed and accuracy have yet to be fully understood—and, in

[38] The minimum is presented here as a range because some CMLs permit certain supervisors to oversee more than one FMV line at some DGS sites. An average figure of 3.5 would not be inappropriate.

[39] As of this writing, the Air Force has developed a preliminary concept of operations (Air Combat Command, *Enabling Concept for Gorgon Stare Quick Reaction Capability*, Appendix D, draft, February 16, 2010, not available to the general public).

[40] The calculation uses the official CMS figures for the standard Predator or Reaper FMV crew: 30 × 3,900. The size of the active-duty Air Force for FY 2011 is estimated to be 332,300. See "USAF Almanac 2011," *Air Force Magazine*, May 2011, p. 40.

[41] DGS-Indiana, for example, now uses a single mission operations commander (MOC) to oversee four FMV missions.

any case, new technologies cannot in themselves answer the basic question of the actual PED *requirements* for motion imagery.

How the Air Force can shape those requirements in a sustainable way to meet the growing demand for motion imagery remains the crucial question for the future of Air Force motion imagery exploitation. It is a concern not only for WAMI imagery but potentially for other future motion imagery collection assets as well. The small cost of video cameras relative to the cost of RPAs and the increasing miniaturization of video technology imply that future ISR platforms will be able to deliver many more motion imagery spots than they do today. But this growth in motion imagery collections offers great rewards as well: It can enable the Air Force to conduct more-coordinated, more-flexible ISR operations than ever before, enabling greater operational responsiveness for the units they support.

Already the Air Force has begun to experiment with more-integrated approaches to PED operations, such as mission type orders (MTOs) that grant the Air Force DCGS a role in tasking collection assets, as well as providing PED, thereby enabling these assets to be more swiftly and dynamically retasked based on the intelligence they provide.[42] The organizational construct described in Chapter Three can help integrate such approaches into the overall ISR operation. In general, understanding and phrasing the demand for motion imagery PED in terms of "output rather than input"—that is to say, in terms of requirements to deliver ISR capabilities to the warfighter rather than requirements to analyze a certain number of motion imagery spots—provides a better path to grow the Air Force DCGS enterprise to meet this demand.[43]

Purpose and Organization of This Report

This report considers how Air Force DCGS motion imagery PED processes can evolve to meet the growing demand for motion imagery–derived intelligence and to take advantage of new operational capabilities. Chapter Two examines related practices in the public and private sectors that are similar to current Air Force motion imagery PED processes and draws lessons from them. Chapter Three proposes a new "area-centric" organizational construct based on these lessons and presents an example of how this might be implemented in an urban scenario. Finally, Chapter Four summarizes the conclusions and recommendations for the Air Force.

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42 An MTO is defined as an order to a unit (here, the DCGS) to perform a mission without specifying how it is to be accomplished. See U.S. Joint Chiefs of Staff, *Personnel Recovery*, Joint Publication 3-50, January 5, 2007a.

43 Deptula, 2010.

CHAPTER TWO

Commercial Practices: Implications for the Air Force

Although motion imagery collection on this scale is a relatively new Air Force ISR capability, the commercial world has employed video technology for decades. For this reason, we sought insights from two established industries: closed-circuit television (CCTV) surveillance and reality television production. Both offer valuable and cautionary lessons.

Another prominent industry in this regard is live sportscasting, particularly in terms of advanced tools and technologies. However, in this report, our focus is specifically on organization and workflow and in those aspects the reality television production crew makes for a stronger point of comparison. Reality television production crews are typically smaller and closer in size to the Air Force PED crew than the teams assembled for sportscasting. Their patterns of operation are also more similar to those of the Air Force DCGS: Unlike major sporting events, which typically are concluded in a matter of hours, reality television production crews must operate continuously for weeks or months at a time. Furthermore, the temporary nature of reality television production facilities and the rather tight budgets under which they must operate (compared with those of the national broadcast networks) can be instructive for an era of limited resources.

The concern has been raised that the comparison of Air Force operations to commercial operations—particularly to an entertainment medium, such as reality television—could be received by some as inappropriate.[1] To allay any such concerns, we wish to emphasize that we consider these correspondences only in terms of process and management issues. The substance and purpose of such operations are clearly extremely different, and we take pains to enumerate the many limitations inherent in our comparisons.

Closed-Circuit Television Surveillance

CCTV surveillance is the civilian enterprise most similar in function to Air Force ISR operations. CCTV systems are used widely to attempt to promote security and safety in the public and private sectors. Much of the video recorded in this manner is reviewed only after the fact; we focus our attention instead on those CCTV surveillance systems that are monitored continuously in real time.

Although the basic task of observing motion imagery is common to both CCTV surveillance and Air Force motion imagery exploitation, the conditions under which the motion imagery must be collected are quite different. Their popular nickname of "eyes in the sky"

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[1] Interestingly, such concerns have never been raised regarding comparisons to the entertainment medium of sportscasting.

notwithstanding, CCTV surveillance cameras are almost always mounted to static structures on the ground. CCTV surveillance cameras are designed to focus over short distances, and many are aimed at a fixed position, unable to pan or zoom for variable resolution. Quality is traded for quantity in CCTV surveillance: Several video cameras might be aimed at the same location from different angles, and there are usually more cameras than there are analysts to monitor them.

In contrast, Air Force motion imagery collection assets are flown thousands of feet overhead on fully mobile platforms, have broad fields of regard, and generally offer multiple levels of resolution. The far greater expense of the platforms on which Air Force motion imagery systems must be mounted drives the trade-off between quality and quantity in the opposite direction.[2] As a result, the Air Force's motion imagery collection assets are far more limited in number and are sufficiently dispersed geographically that analysts do not often have the benefit of simultaneous views of the same target from different angles. Furthermore, Air Force assets must cover broad areas—and often different areas on each succeeding flight—while CCTV surveillance cameras typically cover the same area every day. Whereas no pilot or sensor operator is needed to ensure that CCTV surveillance cameras remain aimed at their targets, these additional elements complicate Air Force motion imagery exploitation considerably.

CCTV surveillance systems are also almost exclusively used to monitor fixed locations that are owned or otherwise under the custodianship of the agency for which the surveillance is conducted, whereas Air Force motion imagery collection assets are usually deployed to observe targets in areas outside of U.S. control. The targets of CCTV surveillance are, therefore, at least in principle, aware that they are being watched—indeed, deterrence of crime and a sense of security are sometimes cited as the primary function of CCTV surveillance—whereas most Air Force targets are presumably unaware that they are being observed.[3] Indeed, great effort is often made to ensure that this is so.

Finally, timeliness and accuracy are less important for CCTV surveillance than for Air Force motion imagery exploitation. Rapid and accurate intelligence analysis is crucial when the Air Force supports troops in contact with the enemy, and even collection activities with a lesser sense of urgency are linked to important military objectives. Civilian agencies, on the other hand, have the luxury to react more deliberately, and, should they fail to react, such "misses" rarely threaten immediate danger to personnel, especially in non–law enforcement areas. Studies indicate that a regular rate of misses is, in fact, expected in the commercial CCTV surveillance industry.[4]

Nevertheless, CCTV surveillance activities exhibit sufficient similarity to Air Force motion imagery exploitation that the correspondences are worth exploring. Mindful of these

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[2] Air Combat Command's MQ-9 fact sheet lists a cost of $53.5 million for a "unit" of four aircraft and associated sensors. The MQ-1 is about $20 million for the same set. See U.S. Air Force, "MQ-1B Predator Fact Sheet," July 20, 2010a; U.S. Air Force, "MQ-9 Reaper Fact Sheet," August 18, 2010b.

[3] For example, see Helen Drew, "CCTV Cameras Big Hit with Public," *Politics Show*, January 16, 2010. Despite the oft-cited deterrent justification for public CCTV surveillance, however, it is unclear that this is borne out by actual crime statistics.

[4] See E. Wallace, C. Diffley, and J. Aldridge, "Good Practice for the Management and Operation of Town Centre CCTV," in *Proceedings of the International Carnahan Conference on Security Technology*, Institute of Electrical and Electronics Engineers, 1996.

differences, however, we have taken as our primary point of comparison only the basic process of monitoring a video display for noteworthy activity.

A casual glance at any DGS operations floor reveals that the Air Force and the CCTV surveillance industry approach this common task very differently. The CCTV surveillance industry seeks efficiency by requiring each employee to monitor several screens at once, while IAs in the Air Force maintain "eyes on" a single screen.[5] To investigate how the Air Force might consider consolidating personnel in line with standard CCTV commercial practices, we examined how dividing attention among multiple video screens could affect IA performance. Our review of the relevant literature indicates that such consolidation could have a significant adverse effect on PED quality.

Surprisingly few rigorous academic studies have investigated the comparative effectiveness of attempting to monitor multiple video screens at the same time. This is perhaps because individual analyst effectiveness is less important to commercial CCTV surveillance than overall cost-effectiveness, which almost inevitably demands minimal use of labor and maximal use of cheap video cameras and entails an acceptable "miss" rate. However, the early days of CCTV surveillance produced several landmark studies on the subject.

After a spate of well-publicized escapes from the maximum-security wings of UK prisons in the early 1970s, the UK Home Office introduced CCTV surveillance to monitor prison grounds. Subsequent studies investigated how effectively a guard could be expected to monitor several video screens at the same time in this context.[6] The studies used staged footage from the interior and exterior of a prison showing a fair amount of normal activity, such as prisoners performing routine maintenance tasks, randomly interspersed with some "suspicious" incidents, such as prisoners running somewhere or stopping to pay undue attention to an exterior wall. Test subjects were informed of some but not all of the types of suspicious activity that might occur and were asked to watch the footage and press a button whenever they believed they had seen a suspicious incident.

When required to monitor only a single screen, all observers recognized all suspicious incidents and raised few false alarms.[7] When asked to monitor a bank of four or nine screens, the rate of success in spotting suspicious incidents fell to 83–84 percent, and the number of false alarms increased significantly.[8] Not surprisingly, the briefer incidents were more likely to be missed, as were those displayed on monitors on the periphery of the multiscreen array. Interestingly, the researchers found no discernible difference in performance between the test groups facing four screens and those facing nine screens, although they offered no hypothesis as to why this was so. Finally, when the testing moved to a grid of 16 screens, the detection rate

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5 Official crew manning standards call for up to three IAs watching each screen, but only two are usually assigned and only one of those is required to keep "eyes on" at all times.

6 A. H. Tickner, E. C. Poulton, A. K. Copeman, and D. C. V. Simmonds, "Monitoring 16 Television Screens Showing Little Movement," *Ergonomics*, Vol. 15, No. 3, 1972, pp. 279–291; A. H. Tickner and E. C. Poulton, "Monitoring up to 16 Synthetic Television Pictures Showing a Great Deal of Movement," *Ergonomics*, Vol. 16, No. 4, 1973, pp. 381–401.

7 For the single-screen experiments, the average was approximately five false detections per person during a one-hour experiment. Unfortunately, not all relevant data were reported, so it is not possible to make a meaningful statement regarding the *rate* of false alarms.

8 The false-detection rates were clearly higher when viewing multiple screens, but the results varied so widely from person to person depending on their temperament that the authors felt that the statistical average value of the increase (anywhere from 50 to 300 percent, depending on the circumstances) was not meaningful.

fell precipitously to 64 percent and below. Tickner et al. concluded, "[W]here it is essential for nothing to be missed, only 1 picture should be watched."

Mind-numbing though the practice may seem in low-intensity operations, the Air Force's insistence on keeping eyes on each video screen is still warranted for those motion imagery streams that require monitoring in near real time. We emphasize, however, that this applies only to motion imagery deemed to require such monitoring; as we discuss in Chapter Three, we expect that the ability to make that distinction will be crucial in the future. Moreover, there are promising technologies in the field of computer vision that could soon allow nonhuman eyes to meet the requirement of keeping eyes on video screens, at least in less time-critical situations, although such tools are not yet available. (We discuss these technologies in the companion report.)

Tickner et al. also determined that the optimal viewing interval for an individual viewer was about one hour: Doubling the interval led to a drop in performance in the second hour, while reducing it to half an hour offered no measurable advantage.[9] A later survey of CCTV operators was consistent with this finding, reporting 30 to 90 minutes as the average desirable viewing time.[10] Finally, it is worth noting that test subjects watching physically smaller screens did not perform as well, even when the distance between the observer and the monitors was adjusted to compensate such that the displays subtended the same visual angle.[11] Tickner et al. could not explain this result, but it is certainly consistent with the preference of the Air Force—and many other organizations—to enlarge the effective display area by adding screens rather than by increasing the resolution.

In the more recent qualitative study, Wallace, Diffley, and Aldridge surveyed operators in 20 UK town center CCTV systems as part of a program to develop methods of improving the effectiveness of CCTV.[12] Trained CCTV operators reported the number of screens they believed they could monitor effectively at one time. The preferred option was between one and four. However, operators agreed that larger monitor banks played an important role in CCTV operations:

> In the main, operators reported that monitor banks were useful for providing a general overview of the camera scenes rather than for picking out detail. Monitor banks may be used more strategically as a cueing method. Images displayed on multiple monitors should be meaningfully grouped and structured wherever possible to aid the operator, for example, town "hot spots" may be displayed on the monitors most directly in the operator's field of view.[13]

The Wallace, Diffley, and Aldridge study indicates some of the benefits of a display that provides context for analysts and offers opportunities for cross-cueing between views of related areas. This approach has important applications to Air Force motion imagery exploitation, as discussed later in this chapter.

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9 In this particular part of the experiment, a detection rate of 71 percent dropped to 62 percent. Tickner et al. stated that this was a statistically significant result.

10 Wallace, Diffley, and Aldridge, 1996.

11 16 × 12 inches versus 8 × 6 inches.

12 Wallace, Diffley, and Aldridge, 1996.

13 Wallace, Diffley, and Aldridge, 1996.

Reality Television Production

The second set of commercial practices we examined concerns the production of so-called reality television programs. Reality television is a relatively recent genre of popular television programming that relies on the unscripted performances of people who are not professional actors (the *cast members*) within constructed situations for its dramatic or comic interest.[14] Commercial television production studios vary considerably in size, but the small- to mid-sized studios that produce the bulk of such programming in the United States today primarily employ a dozen or more fixed cameras and a handful of mobile cameras, which is comparable in scale to the amount of motion imagery exploited at a DGS site. We further focus our attention on that particular subgenre of reality television programs that centers on events that transpire in one or more communal living areas or workspaces.[15]

Many of the warnings regarding the comparison of Air Force DCGS operations to CCTV are equally valid here. One more important caveat is that reality television producers typically have the benefit of knowing ahead of time at least a loose "script" underlying the activity on screen, so they can often anticipate the objectives of the cast members—whereas Air Force intelligence analysts must strive to infer the activities and intentions of their targets, of which they might know little at the outset. For this reason, as we consider reality television production crews in this context, we focus on how they work together to capture *unplanned* interactions and unexpected events. Collecting these unscripted moments is a high priority for reality television production crews; such moments, from which the genre derives its name, are often prominently featured in reality television programming.

Although reality television production is obviously very different in function from Air Force motion imagery exploitation, the activities involved and the interactions among their respective crews have surprisingly many points of correspondence: Both enterprises entail 24/7 operations to observe and analyze streaming video; both report and record events in near real time, as well as conduct retrospective analysis to establish patterns of activity and to investigate unusual incidents; and both make use of dynamic retasking and cross-cueing of sensors. The experiences of the reality television industry in these respects are therefore worth examining as the Air Force prepares for the increasing prevalence of motion imagery in ISR operations. We investigated this through semistructured interviews with professionals in the industry and direct observation of production activities.

The Control Room

The nerve center of reality television production activity is the control room. This is where the bulk of the production crew works during the filming of the show, the primary exception

[14] Although not the first of its kind, the breakthrough program for this genre on U.S. television is generally considered to be the Bunim-Murray production "The Real World," which first aired on MTV in 1992. The proliferation of handheld, high-definition television cameras has helped fuel an explosion of such programming, particularly on cable channels, since 2000. Unlike documentary or journalistic subjects, reality television cast members are typically compensated for their performances, which might be coached or coaxed to enhance entertainment value.

[15] These are the programs that must engage in continuous surveillance of multiple locations, recording large amounts of video footage for later use. Travelogue, home improvement, and other reality television programs of an episodic nature tend to be filmed in a more targeted manner.

being the mobile camera crews, which, of course, must be on set.[16] An example of such a control room is shown in Figure 2.1. The distinguishing feature of the control room is its central, aggregate video display: All video feeds from the set are displayed together in a bank of monitors on a single wall via CCTV, and all workstations face this wall.[17] It is worth noting, however, that video feeds from other sets are *not* typically included. To the extent that this could be done, the modest added contextual value is not generally considered worth the expense; furthermore, the extra screens can constitute a distraction.

Although the reality television control room is almost always located on-site, close to the set, it is always distinct from the set being filmed. Most reality television crew members need not access the set, and, as a rule, the cast members never enter the control room. Insofar as motion imagery exploitation activity is concerned, the reality television control room could be located somewhere else entirely.[18] The control room setup described here is, in fact, common to *all* television production, from scripted shows to live sportscasting; it has become so prevalent that some companies do nothing but set up control rooms for other companies.[19]

Figure 2.1
Crew Members Directing Operations in a Control Room

SOURCE: Photos courtesy of Lauralee Jarvis, used with permission.
RAND *TR1133-2.1*

16 Support staff, off-site management, and postproduction duties are not included in this description of the production crew. Mobile camera crews are discussed but not counted toward crew size because their Air Force counterparts (sensor operators and pilots) work outside the Air Force DCGS.

17 The arrival of inexpensive, high-definition flat screens has liberated the design somewhat. Instead of an imposing bank of midsized cathode ray tube monitors, the control room we observed displayed 24 video feeds across two 42-inch liquid crystal display screens.

18 The control room is built on-site because this allows the use of CCTV to bring in video from the set. Reality television crew members also perform tasks on set in addition to video analysis that have no analogue in DGS operations, such as interviewing cast members and preparing the activities in which the cast members will participate. We are told that this arrangement also simplifies the catering.

19 That the Air Force does not use this type of setup was greeted with universal astonishment, even disbelief, by the television professionals interviewed.

Personnel and Organization

Like that of the Air Force motion imagery PED crew, the structure of the reality television production crew was adapted quickly from existing templates to take advantage of new capabilities. As both structures evolved to take better advantage of these capabilities, some remarkable convergences developed. Table 2.1 summarizes the roles and responsibilities of each of the main reality television production staff positions and their correspondence to Air Force DCGS positions. Each of the corresponding positions merits discussion in some detail.

The aptly named show-runner manages the overall operation and is ultimately held responsible for its success or failure. Although the show-runner handles resource and personnel issues directly, he or she generally leaves oversight of day-to-day operations of the video systems on set in the hands of the director. This division of duties is pervasive in the television production industry, across all programming genres. The Air Force adopts a similar division between the MOC and the IMS for exploitation crews working in all intelligence domains. The experience of the television production industry suggests that this operational framework is robust for motion imagery exploitation.

The role of the director proves to be the most significant point of correspondence between Air Force motion imagery exploitation and reality television production. The director stands at the front of the control room, closest to the combined video display, and uses this bird's-eye view to redirect mobile camera crews and to instruct the operators of fixed cameras to pan or zoom as needed.[20] Generally speaking, the director is charged with what the Air Force would call maintaining *situational understanding*, managing *ad hoc collections*, and looking for *cross-cueing opportunities*.[21]

Although the Air Force motion imagery PED crew includes an IMS with certain similar duties, as indicated by Table 2.1, some of these duties may be relegated to a CAN, and, in any case, the current Air Force DCGS structure does not afford the IMS the degree of autonomy and responsibility exercised by the director of a television production. The importance of the role of the director in multicamera motion imagery PED is an important insight from the practices of reality television production. How this could be applied to the Air Force context is discussed in greater depth in Chapter Three.

The cross-cueing aspect of reality television production is perhaps the most unanticipated point of comparison with DGS operations. In reality television production, the director redirects mobile camera crews in real time to cover activities of interest. The director is in direct communication with the camera crews via push-to-talk radio and does not require an intermediary.[22] These dynamic adjustments are neither rare nor unexpected: Finding cross-cueing

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[20] The reality television director usually does, in fact, stand at the front; the proverbial director's chair is largely reserved for rest periods. In some newer setups, the director can adjust fixed cameras directly without going through the equivalent of a sensor operator. Although the potential for such direct involvement is worth exploring, here we focus on the more traditional arrangement for comparison because the Air Force DCGS is not currently granted the equivalent of this tasking authority.

[21] We use Air Force terms throughout this report to describe the director's duties, although they are foreign to the reality television production industry.

[22] When asked how this would work if several important events occurred in different locations at the same time, one story producer replied, "That's when the shouting starts." The Air Force's reliance on Internet chat rooms rather than radio communications leads to the opposite effect, however: When activity spikes on the DGS operations floor, conversation yields to the muted patter of keystrokes.

Table 2.1
Comparison of the Air Force Motion Imagery Exploitation Crew and the Reality Television Production Crew

Responsibility	Air Force Motion Imagery PED Crew	Reality TV Production Crew
Manage entire operation	MOC or ISRMC	Show-runner (or executive producer)[a]
Oversee daily operations	IMS	Director
Watch for cross-cueing opportunities	CAN[b]	Director
Liaison	TACOM (or screener)	AD
Generate products	IRE	Story producer/editor[c]
Maintain eyes on and log events	IA	Associate story producer

NOTE: ISRMC = ISR mission commander. IMS = imagery mission supervisor. CAN = correlation analyst. TACOM = tactical communicator. AD = assistant director. IRE = imagery report editor.

[a] The highest echelon in the reality television crew is more stylized than is reflected here. In addition to the executive producer, a crew can have one or more co–executive producers, considered slightly lower in the pecking order. There can also be one or more supervising producers, slightly lower still. *Show-runner* is not a formal job title but an informal designation given to the highest-ranking producer who devotes full attention to the show (some producers work on more than one show). Producers at this level might take turns overseeing different shifts, much as the Air Force rotates through different MOCs to support 24/7 operations.

[b] Although the purpose of the CAN is to coordinate cross-cueing opportunities with others, the lack of such opportunities can lead to this position taking on the character of the TACOM. Not all PED crews have a CAN.

[c] The difference between the story editor and story producer positions lies largely in their postproduction duties. Story producers write a script on paper for each episode, while story editors string together the requisite footage.

opportunities and capitalizing on them is one of the director's primary responsibilities. The director does not merely watch over the activities of others; he or she plays an active and vital role in the production process.[23]

The AD is somewhat of a counterpart to the Air Force DCGS TACOM in that both act as liaisons to other parties. However, the flow of information differs in direction. The TACOM generally relays the requirements of the supported unit up to the PED crew, whereas the AD relays the director's requirements down to other subordinate personnel. They also use different media to manage this flow: The AD communicates by voice (often by radio) that is accessible to all, whereas the TACOM works within multiple separate chat rooms. Thus, although the AD might speak with a single, authoritative voice, the TACOM must be more interactive and must manage more-fragmented communications. Nevertheless, we can still draw lessons from the AD position. As we discuss later in this chapter, the Air Force might find audio more efficient than text-based communication in some of these situations, and there might also be ways to clarify the lines of communication that do not inhibit interactivity.

The story editors, story producers, and assistant story producers (referred to collectively hereafter as *story producers*) are the workhorses of reality television production, much as IAs are to the Air Force DCGS. Story producers watch the streaming video, report on the events in real time (an activity known as *live logging*), and produce final reports (or multimedia equivalents)

[23] Directors also direct the activity of the cast members, to the extent that certain preplanned events or set pieces (e.g., cast member "elimination" ceremonies) must be stage-managed.

for later use.[24] Story producers also write up *hot sheets* for the next shift to inform them of the important events that transpired. This helps story producers in the next shift understand better the context of what they are watching and helps them anticipate events when such is possible.[25] These hot sheets are distributed up to the producers to keep them apprised of the events as well. We observed a similar informal practice among some IMSs and MOCs at various DGS sites to cope with shift changes, although such notes are neither archived nor disseminated.

Story producers also are largely responsible for building the extensive multimedia databases each reality television production studio maintains. Virtually every scrap of video from every camera is recorded and entered into a large database on a common server. Live logs are added to significant clips to tag them for later reference, and, in postproduction, the story producers scour the footage to add tags and ensure consistent metadata, such as time, location, and individuals on camera. The purpose of this postproduction work is to facilitate later exploitation.

Reality television production makes extensive use of multimedia database management and interface programs. U.S. industry standards are the well-established PilotWare (see Figure 2.2) and the more recent Teresis Media Library system.[26] Cinegy provides software popular among European reality television production companies. Dalet is used by several large broadcast networks for similar purposes, and Front Porch Digital provides back-end vir-

Figure 2.2
PilotWare Data-Entry Interface

RAND *TR1133-2.2*

[24] Live logging is common practice in sportscasting as well.

[25] Although all or nearly all story producers contribute written notes, usually only one of them compiles the final hot sheet.

[26] PilotWare is so widely used in the industry that familiarity with the interface is occasionally listed as a requirement in posted job descriptions.

tualized management solutions to support such software for much of the commercial television broadcast industry.

The latest versions of these software programs allow story producers to enter live logs directly, where they will be automatically associated with the corresponding video clips, and the metadata-entry screens offer customized drop-down menus to make tagging easy and consistent. Still images can also be logged and entered in the same way. Multimedia databases such as these permit rapid searching by keyword and allow analysts to link directly to the video content instead of relying on screen captures alone. This facilitates information sharing and subsequent analysis of the data.[27]

The relative ranks of the different types of story producer and different types of imagery analyst are not quite equivalent because the purposes of Air Force motion imagery exploitation and reality television production dictate different priorities. The primary product of Air Force motion imagery exploitation is near-real-time interaction with supported units, the final written reports being largely records of what transpired during the those interactions. The reverse is true for reality television: The final presentation *is* the product, the real-time interaction being only a means to that end. Thus, those who generate the written reports are ranked higher in reality television production, whereas the IREs in the Air Force motion imagery PED crew are not. Both enterprises have aligned their expertise appropriately with their priorities.

One other aspect of the live logging process merits attention. Story producers are not assigned to watch specific cameras but rather to follow specific individuals on camera.[28] In other words, the live logging process is what the Air Force would call *target-centric* as opposed to *platform-centric*. Unlike the targets of Air Force ISR operations, however, the "targets" of reality television crews move frequently from camera to camera when cameras are in close proximity. Moreover, the most basic aspect of Air Force motion imagery PED—knowing whom and what one is looking at—is rarely necessary in reality television production because crews know this ahead of time. The live logging is there solely to assist in understanding intent and activity—that is, to conduct what the Air Force would call *higher phases of exploitation*.[29] Thus, the target-centric nature of the live analysis is less a contrast with Air Force practice than a reinforcement of intelligence community practices in higher phases of exploitation.

Finally, we would be remiss not to mention one last major difference between reality television production and Air Force motion imagery exploitation: Reality television crews exploit audio and video signals together. Both data streams are logged (or transcribed) in real time and archived in the database for later reference. The director often cross-cues between these media—for example, by directing a mobile camera crew to investigate an unusual noise or an argument occurring off-camera.

It would be a stretch to consider reality television a model of multi-INT fusion, however. In reality television production, all of the cast members wear microphones, and the audio and

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[27] There are also other means of exchanging information. While we were visiting one DGS site, we observed an IA giving instructions to an IRE to record an incident we had witnessed an hour earlier. The IA had archived several screenshots and wished to indicate which to use in the final product. The IA handed the IRE a sketch on a yellow sticky note.

[28] When live logging, story producers usually watch four screens (a *quad split*) at a time, sometimes more. This is consistent with an acceptable miss rate—lives are not on the line, and any errors or omissions can be corrected in postproduction.

[29] In contrast to intelligence analysis, however, the objective of higher-phase story production is not to report faithfully on all that occurs so much as to tease out footage of those events that could be brought together to tell a compelling story. The process of story production involves a certain amount of creativity in addition to detective work.

video signals on set are already tightly integrated before they reach the control room. Nevertheless, the multimedia nature of reality television production suggests that this crew structure and control room format has the potential to extend to multi-INT operations—it has room to grow.

Lessons from the Commercial Sector

These insights from the CCTV surveillance and reality television production industries lead to several recommendations to enhance Air Force motion imagery PED processes. Some of these can be implemented independently, and we discuss those in this section. Taken together, however, these insights also suggest a new organizational construct, which we describe in detail in Chapter Three.

The Control Room Format and the Common Operational Picture Display

CCTV surveillance operations and virtually all television production studios (not just reality television) use the same workspace format: Rows of workstations face an aggregated data and video display (see Figure 2.3). In reality television production, it is most common for the workstations to be spaced so as to allow supervisors to walk right up to the aggregated display. This is also similar to the design of Air Force command centers. We recommend that the Air Force adopt this format for motion imagery PED.

A few of the smaller DGS sites already approximate this format. A competing arrangement, in use at others, is a 360-degree arena, with a central command post and separate motion imagery exploitation crews arrayed around it in equal sectors. This format facilitates some higher management functions in that it places the MOC in roughly equal proximity to all analysts. However, when the motion imagery collections are no longer isolated—when cross-cueing potential described earlier becomes paramount—the content of the screens becomes a dynamic driver of PED operations, and it would be preferable for the MOC to have all necessary information visible at a glance.[30]

Another competing format is a cluster or "pod" arrangement that groups together motion imagery analysts with IMINT and SIGINT analysts working to support the same missions or analyzing collections from the same geographic area. This is intended to facilitate multi-INT operations—a worthy goal. However, this arrangement is not easily scalable, in the sense that only a handful of analysts can effectively man a cluster. The Air Force should instead plan with an eye toward the future, when multi-INT operations might require a "super crew" of dozens of analysts and working around a common table is no longer practical. The control room format scales well, which is one reason that virtually all commercial video enterprises, large and small, use it.

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[30] At the 2010 Winter Olympics in Vancouver, organizers built a large temporary International Broadcast Center housing seven control rooms—yet, even with competing networks, the need for situational awareness was recognized as paramount:

> Production personnel sitting at any desktop in the [International Broadcast Center] could see any network, any channel and any venue with the click of a mouse. People could also look at the incoming [television] signals on larger monitors. . . . This saved lots of time and greatly increased efficiency. (Michael Grotticelli, "CTV at the Winter Olympics," *Broadcast Engineering*, Vol. 52, No. 7, July 2010, pp. 30–35)

Figure 2.3
The Control Room Format

RAND *TR1133-2.3*

There are other concerns that come into play when designing a seating arrangement, such as the placement of equipment, the need to run cabling, and the shape of the room. Even when the control room format is easy to implement, it might be worthwhile to experiment with this format before doing so. The Air Force DCGS experimental test bed, DGS-X, would be an appropriate venue to test the control room format.

The focal point of the control room format is the aggregated data and video display. It need not be large—it is not necessary to present all motion imagery in full resolution—but it should include all motion imagery being exploited within that room.[31] For the Air Force, the purpose of the display would be to deliver a bird's-eye view of what is being collected and to provide a common operational picture (COP) to the analysts. For this reason, we refer to it as the *COP display*.

Where possible, the Air Force should include other geolocated intelligence data in the COP display to improve situational awareness and to deliver the fullest operational picture. Unlike CCTV surveillance operations and reality television production studios, the Air Force also collects data across infrared wavelengths, from radar, and from various measurement and signal intelligence and SIGINT sensors. Provided that the pipelines are available to share the data, it costs little to add an extra video screen or an additional subpicture to the COP display. Even data from such systems as Blue Force Tracker should be considered candidates for inclusion in the COP display. Multi-INT cross-cueing opportunities are easier to recognize when the locations of all relevant assets are displayed side by side.

Recognition of cross-cueing opportunities might be even easier if this information could be overlaid on the same map. Interactive displays of this type are increasingly inexpensive.

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[31] When the operations floor contains more than one control room, as envisioned in Chapter Three, each aggregated display need contain only the motion imagery exploited within its control room.

The main obstacle to single-map integration appears to be interoperability between different data formats and computer systems. Multilevel security concerns can also obstruct integration of data from all INTs. However, the increasing prevalence of Google Earth and greater standardization in data formats across all U.S. military computer systems might ultimately permit all geolocated data to be displayed together.[32] Even when multi-INT fusion is not indicated, making available to analysts the fullest context for the collections they analyze can only improve the quality of PED going forward. As ISR capabilities continue to grow, understanding context and correlations will be crucial to achieve the best use of the intelligence gathered.

The Air Force should also use the COP display to enhance the internal situational awareness of the Air Force DCGS. During the course of our observations at various DGS sites, many analysts and commanders expressed the desire to be able to see at a glance what was being done at other DGS sites. This was especially pronounced when PED for a single ISR mission was spread across multiple sites, and supervisors at the primary mission site wanted to know how analysis at subsidiary sites was progressing. From a managerial point of view, having this level of internal situational awareness would also facilitate real-time collaboration across the Air Force DCGS, in the spirit of the "federated" aspect of the enterprise.

As a final note on this subject, if and when the full WAMI image becomes available at the DCGS, an intuitive and user-friendly way to explore this large footprint would be through the use of touch screens to scroll and expand portions of the footage. Such interactive screens could be integrated into the COP display for the supervisor to use and could be used by analysts at their workstations. An analyst with this tool at his or her fingertips could search in and around the video chips to look for impending threats before they enter the scene or to follow vehicles after they leave. Such a touch screen would also be useful when exploring very high-resolution still imagery.

Although there is little that can be done with a touch screen that cannot be done with a computer mouse, for these sorts of graphical manipulations, a touch screen system would be more intuitive to the analyst and likely would permit more-rapid exploration of the image. Although today's motion imagery is collected in support of low-intensity, irregular warfare, the Air Force should prepare for the possibility of sustained high-intensity operations in the future.

Multimedia Databases

In an age of increasingly compact data repositories, when a terabyte of data can fit comfortably in the palm of one's hand, digital storage space requirements per se do not pose a technical barrier to the Air Force maintaining all of its current motion imagery collections in a digital format—and there is every reason to believe that computer storage capabilities will keep pace with the increase in Air Force motion imagery collections.[33] However, making this vast trove of information searchable and accessible to all authorized users who need it presents a far more challenging problem. We address these issues in the companion report.

For our purposes, however, we observe that keeping even a few months' worth of motion imagery collections available would have great value and that this problem is much more trac-

32 The open standard of the Extensible Markup Language offers one possible framework for standardizing data formats, including Microsoft Office's post-2007 format (Open Office Extensible Markup Language, e.g., .docx) and Google Earth's KML.

33 Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Electronics Magazine*, Vol. 38, No. 8, 1965. In a few years, no doubt, the notion of terabyte of data fitting into the palm of one's hand will seem quaint.

table. Although the numbers vary widely and we do not attempt to make a more explicit quantitative comparison, we note that a typical reality television production crew might manage between 12 and 16 cameras around the clock, which is of the same order of magnitude as the motion imagery intake that an individual DGS site can be expected to experience in current operations.[34] The editors who ultimately exploit this footage do not rewatch all or even most of it; they instead rely heavily on the live logging notes taken during filming to sift through the footage and produce the narrative.[35] The multimedia databases or digital asset management systems that facilitate this are effective at handling this amount of data and are commercially available.[36]

For the Air Force, creating a database to include motion imagery (as well as the traditional still imagery that is currently archived) would eliminate the need to use email or file transfer protocol (FTP) to exchange such data within the Air Force DCGS. Making such a database searchable and available to its federated partners would also allow other analysts to mine through the volumes of archived motion imagery to glean additional intelligence. Automatically including chat transcripts to the database, linked to the associated time-marks on the motion imagery, would greatly facilitate such later analysis. Building and maintaining a multimedia database is the practice of every television production studio, even those restricted to shoestring budgets; the Air Force should strive to provide similar capabilities to analysts to derive maximal advantage from motion imagery collections.

Digital asset management software also usually offers a digital video recorder (DVR)–like capability to pause, rewind, and fast-forward "live" streaming video. This would permit IAs to review and confirm significant events as a team. DGS-Kansas has experimented along these lines to an extent by displaying on a large wall, visible to the entire PED crew, the original video feed delayed by about 20 to 30 seconds.[37] If an IA calls out a possible incident, another IA (or IMS) can look to the delayed screen to verify the first IA's interpretation. An actual TiVo® box is used to achieve this, demonstrating that some existing commercial technologies—even certain consumer electronics—can be adapted to enhance Air Force motion imagery exploitation. The Air Force should work to give IAs the same capabilities at their workstations that many already enjoy with their personal DVRs at home.[38]

The greatest potential for digital asset management software to enhance ISR capabilities, however, lies in the realm of later-phase or higher-tier analysis, also referred to as *forensic analy-*

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34 The figures offered represent shows filmed on a continuous basis. Some might employ more cameras, and some fewer. Others film only for a week or so at a time and then take long breaks. A more rigorous quantitative analysis should address these differences to determine whether the particulars of these production schedules ease requirements in a way that the Air Force cannot.

35 For scaling purposes, typically an individual episode is based largely on a few days' worth of footage (from all cameras), and story producers usually require one to two weeks to assemble the episode to the stage relevant here. (Final polishing can take several more weeks if time and budgets allow.)

36 We specify a *multimedia* database because these databases also include audio files and still imagery. Because they require far less storage space, however, the capability of archiving these additional media is almost always included as a matter of course.

37 Since our initial observation, it has been reported to us that this is now the practice at all Air National Guard DGS sites.

38 Some studies have also proposed adding a "telestrator-like" feature to video software. (For example, see Nathan Hodge, "Madden NFL for Military's Drone Video Analysts," *Wired*, January 11, 2010). Although this certainly could assist near-real-time communications, the free-form nature of the interface makes it ill-suited to searching and standardization. It should be considered as a supplement to, not a replacement for, metadata and tagging.

sis. At present, only motion imagery intelligence products—reports—are generally made available outside the DCGS. Storing all motion imagery collections in an accessible and searchable format would allow intelligence analysts to use these data in higher phases of exploitation—in particular, in forms of "negative" exploitation, i.e., obtaining knowledge from the absence of events, because, by their nature, incident reports usually deal only with activities that occurred or were expected to occur. Regardless of which organizations are ultimately tasked to conduct later-phase analysis, publishing and maintaining a comprehensive database of motion imagery collections would be a valuable Air Force contribution to the intelligence community.

The 11th Intelligence Squadron (IS) (SOF) already uses General Dynamics's Multi-INT Analysis and Archive System™ for these purposes, and DGS-1 has recently begun experimenting with the same system, although, as of this writing, its search capabilities are not yet particularly well-leveraged.[39] Other similar systems exist to manage motion imagery and integrate it with still imagery and audio libraries.[40] Lockheed Martin and Harris are developing the National System for Geo-Intelligence Video Services, which offers similar capabilities for this arena, as well as some WAMI capabilities, and is based on Harris's commercial Invenio solutions for digital asset management.[41] The Air Force might want to consider adapting existing commercial technologies to this purpose as well and, in any event, would do well to investigate these technologies to understand their capabilities.

Some commercial software products are limited in terms of the video formats they accept, however, and there are important interoperability and information assurance issues that must be addressed. We recommend that the Air Force approach the acquisition of a multimedia database at the Air Force DCGS level (if not higher) rather than for individual DGS sites separately, to address these concerns better.

Communication Practices

For near-real-time communications, the Air Force DCGS relies heavily on Internet relay chat (IRC) rooms, generally referred to simply as *chat* or *mIRC chat*.[42] At DGS sites today, it is common for analysts to participate in a dozen chat rooms at once. Although this practice works well for the Air Force under present circumstances, it is worth asking why the commercial world has not done the same.

Television production crews working in nearly all programming genres instead use push-to-talk radio ("walkie-talkies") and integrated headsets (with both earphones and microphones)

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[39] One airman explained that the software in question had been adopted only to make it easier to build PowerPoint slides. The TiVo-like ability to review data collected minutes earlier was also appreciated, but this only scratches the surface of what such digital asset management software can do.

[40] The aforementioned PilotWare, Teresis, and Cinegy are examples of such media management software. Such software is typically tailored to each customer's needs. The creator of PilotWare noted in personal communications that the software could be used as a front end to an industrial-sized database (e.g., Oracle) to handle more data.

[41] National System for Geo-Intelligence Video Services came out of the U.S. Joint Forces Command program known as Valiant Angel, developed by Lockheed Martin, and incorporates Harris's Full-Motion Video Asset Management Engine, which is based on Harris's commercial Invenio product. U.S. Central Command chose not to deploy Valiant Angel in theater as originally scheduled. See Ben Iannotta, "Playing Catch-Up," *C4ISR Journal*, October 1, 2009; Ben Iannotta, "Fallen Angel," *C4ISR Journal*, July 1, 2010; and Paul Richfield, "New Video System Takes on Wide-Area Sensor Challenge," *Defense Systems*, April 6, 2011.

[42] mIRC is the world's most popular IRC client, launched in 1995 by Khaled Mardam-Bey. The intended meaning of the lowercase "m" in the abbreviation has never been definitively explained.

for communication within the control room and between the control room and crew members in the field. In part, this practice merely reflects habit and preference: Producers and directors are, in general, accustomed to expressing urgency—and asserting authority—in a rather vocal manner. It is also somewhat a matter of practicality and expense: It is more convenient to wear a headset than it is to carry a computer, especially for mobile crew members already laden with equipment, and it would not be cost-effective to hire additional crew members to work the chat rooms. Moreover, chat rooms would take up space on the video screen, and producers have been reluctant to pay for workstations with multiple screens.

From an organizational point of view, however, the main reason television production crews do not use text-based communications is that, within the control room format, the supervisors are constantly in motion. Unlike Air Force MOCs and IMSs, who typically must be seated at their workstations, producers and directors are usually found on their feet or perched temporarily on the edge of a table. They walk back and forth in front of the aggregated video display, looking for cross-cueing opportunities and checking to see that their directives in that regard have been realized. If the Air Force adopts this format, as we recommend, giving supervisors the option to use headsets would allow them the freedom to roam the operations floor and to make full use of the COP display to improve their situational awareness.

A secondary reason, but of equal importance here, is that all of the television professionals with whom we spoke believed that attempting to participate in chat rooms while watching motion imagery would degrade their ability to exploit that imagery because chat rooms compete for visual attention with blinking cursors and colorful scrolling text, even when the analyst is not actively participating. By contrast, experienced crew members in the control room are able to multitask—to keep abreast of (or, as the case may be, to tune out) multiple simultaneous conversations on the radio while also logging live video. (Doing so effectively is one of the skills that indicates an experienced crew member.)

Currently, Air Force PED crews include separate IAs (or one IA and one TACOM) to keep eyes on motion imagery and to communicate what they observe with others. This is unavoidable when the eyes-on requirement prevents the IA from reading the chat room. If the Air Force DCGS were to shift from text-based communications to spoken communications (radio), however, providing a headset to the IA maintaining eyes on might allow the IA to handle the communications as well, thereby offering a way to consolidate these positions. Alternatively, providing both IAs with headsets could permit them to provide backup for one another. Such a shift would, however, represent a significant procedural change.

The Air Force has already taken a step in this direction. The MCE and the supported unit have long communicated by radio; the new Distributed Mission Crew Construct, if adopted in full, would permit Air Force PED crews to listen to (but not participate in) these communications.[43] Although there is an understandable desire to avoid unnecessary radio chatter, allowing Air Force PED analysts to participate in the conversation has the potential to improve their situational awareness and to foster the relationships of trust that are vital to successful virtual collaboration.[44] The Air Force should continue to work to integrate its PED personnel further with the missions they support. Even when the MCE and supported unit faithfully copy the content of their conversation into the chat rooms—and they do not always do so—text does

[43] As of this writing, experiments along these lines are under way.

[44] Trust, habitual relationships, and virtual collaboration tools are discussed in this context in the companion document.

not carry the same emotional freighting as speech. The intensity of operations can be lost in the translation.

However, chat rooms are excellent at indicating who is speaking to whom, whereas, with spoken communications alone, there is more potential for confusion, particularly in the future, when PED crews might support more than one unit.[45] CCTV surveillance operations have also shown the potential for distraction with heavy reliance on voice communications.[46] As a smaller step in this direction, therefore, we recommend equipping IAs with headsets enabled with speech-to-text capability, or at least giving such headsets to the IAs charged with the responsibility for communications. With such headsets, IAs would have the option to speak what they see, and the information would enter existing Air Force chat rooms without additional keystrokes, freeing them to focus on other aspects of their work. This would not require organizational change and would permit continued reliance on chat rooms.

Note that we specify speech-to-text only: Good text-to-speech synthesizers are not yet readily available, and one can only imagine that a robotic voice droning in the ear would present an additional distraction. It is also difficult to see how text-to-speech could work well with the dozen or more chat rooms that are typically kept open at the same time. Thus, although such headsets would not enable full chat room participation and therefore would not enable the IA maintaining eyes on to handle all communications, they nevertheless are an inexpensive option that should be easy to provide.

A related issue regarding text-based communications that has arisen repeatedly in our investigations is the need for greater discipline in chat rooms—in particular, the need to establish a common lexicon for chat.[47] Air Force radio communications are controlled—and joint "brevity" words have been in common use for decades—but Air Force text-based communications have yet to be similarly standardized. This is particularly important because chat text is often cut and pasted directly into reports; no single practice would facilitate archiving these reports more than the consistent use of keywords. Thanks to the increasing sophistication of linguistic interpretation algorithms, confusion regarding spelling, syntax, and capitalization has largely evaporated, so perfect typing and complete standardization of word forms are no longer necessary. The discipline required to achieve sufficiently standardized text-based communications should now be no greater than for radio.

It is worth noting as well that the extra step of cutting and pasting chat text into software, such as Open Office or Microsoft Word, would not be necessary if the chat rooms were part of a richer communication environment that supported document creation natively. Such environments have been developed in the commercial world, though none are in widespread use. Some applications, such as Google Buzz and Google Wave, for example, permit the user to embed hyperlinks, images, and certain applications (e.g., Google Earth) directly into an email-

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45 We heard some amusing anecdotes of such confusion occurring on reality television production sets.

46 Hina Keval and Martina Angela Sasse, "'Not the Usual Suspects': A Study of Factors Reducing the Effectiveness of CCTV," *Security Journal*, Vol. 23, No. 2, 2010, pp. 134–154.

47 The use of "whisper" chats, exclusively between two individuals, although valuable for conveying urgent information, has also been noted as having the potential to fragment communications. The Air Force is already working to restrict the use of whisper chat to information not vital to missions.

type document.[48] The Air Force should continue to look for ways to use existing commercial technologies to enhance its operations, eliminating the need to transfer data between software programs whenever possible.

Conclusion

The commercial world has developed ways to address many of the challenges of processing, exploiting, and disseminating large amounts of real-time motion imagery. Adapting the practices described in this chapter to the Air Force DCGS can improve the Air Force's ability to meet the future demand for motion imagery PED and to take advantage of the opportunities for cross-cueing and situational awareness that future systems will provide.

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[48] Although Google has chosen not to support Google Wave further, the capability was well-demonstrated. The product was pulled due to lack of consumer interest rather than any technical shortcomings. See Karim R. Lakhani, "Google Wave Decision Shows Strong Innovation Management," *Harvard Business Review Blog Network*, August 5, 2010.

CHAPTER THREE

Way Ahead: Area-Centric Operations

Thus far, we have examined the activities of a single PED crew through the lens of commercial operations. In this chapter, we look at the larger structure of multiple PED crews and propose in some detail a new organizational construct, which we name *area-centric operations.* Although the recommendations presented in Chapter Two stand on their own merits, they also pave the way for adopting this construct.

A wider view of commercial television production reveals a straightforward and pervasive organizational construct for the large-scale collection and management of motion imagery. For day-to-day, near-real-time operations, all motion imagery collected from a given area (or set) is managed together by one crew, while that acquired from different areas is managed by different crews. It is only for later analysis that motion imagery from all locations is brought together. (In commercial television, this is done in postproduction.) We believe that an organizational construct based on these principles would prepare the Air Force DCGS to manage the growth in motion imagery collections in the years to come.

Currently, the Air Force DCGS conducts near-real-time motion imagery exploitation in a platform-centric manner, meaning that the motion imagery collected by each platform is first observed and analyzed independently of that collected from other platforms.[1] Until now, this has been an eminently sensible practice. Conventional Air Force motion imagery collection assets typically have been widely dispersed in deployment—especially given the simultaneous operations in Iraq and Afghanistan—so there has been little, if any, potential for overlap in coverage. These assets have also, until very recently, carried only a single, narrow-field-of-view FMV sensor, which effectively restricted support to only one ground unit at a time. Furthermore, in accordance with the traditional 72-hour planning cycle of the air tasking order, intelligence derived from one collection asset generally has been used to task future missions rather than to dynamically retask concurrent missions. And using standard motion imagery exploitation crews is, of course, a simple way to allocate and assign personnel.

All of these facts are now changing. The number of Air Force motion imagery collection assets is growing swiftly, and it will soon be possible, if not routine, to fly them in close proximity to one another. New assets are also being equipped with multiple camera systems, notably WAMI systems that offer the equivalent of a small fleet of cameras. Moreover, the demonstrated ability of motion imagery collections to lead to actionable intelligence in near real time has accelerated the shift from the traditional tasking and collection planning cycle toward dynamic retasking and ad hoc collection processes. Finally, as indicated in Chapter One, the

[1] In subsequent, non–real-time PED, analysts can fuse data from multiple platforms.

rapid growth in motion imagery collections implies that assigning a standard motion imagery exploitation crew to each motion imagery spot will simply no longer be feasible.

For these reasons, we believe that the time is ripe for the Air Force to consider a new organizational construct for motion imagery exploitation. The tremendous growth in motion imagery collections poses a challenge to current operations but also offers the promise of more-flexible, more-coordinated ISR operations than ever before. The capability to execute ISR operations that are more flexible and more coordinated demands PED capabilities to match.

First, the organizational construct should make it easier to identify and capitalize on opportunities for self-cueing and cross-cueing, including cross-cueing between different motion imagery collection assets. As surveillance coverage grows denser, the opportunities for self-cueing and cross-cueing will multiply. The responsibilities to look for such opportunities, and to request any necessary retasking, should be clearly assigned.

Second, the organizational construct should be robust, flexible, and appropriately scaled: It should be robust in the sense that it can handle sudden spikes in demand effectively; it should be flexible in the sense that it can support varying needs of multiple missions at the same time; and it should be appropriately scaled such that PED staffing levels match PED requirements at any given time as closely as possible. With multiple cameras on multiple platforms, the door is now open to tasking motion imagery collection assets in a more flexible way, using one platform to support many missions or using many platforms to support the same mission.

Third, the organizational construct should anticipate the potential need for what we call *PED triage* to determine which motion imagery must be watched and analyzed in real time and which can be reserved for later exploitation. At the moment, the Air Force is able to keep eyes on all incoming motion imagery, but, as the sheer quantity of motion imagery collected grows without bound, the Air Force will eventually need to apply its PED resources selectively rather than uniformly.[2] Any new approach should incorporate a process to manage this transition in a seamless way.

Finally, although we have emphasized the importance of motion imagery to near-real-time PED operations, other INTs also provide essential intelligence, even if these collections take longer to process and exploit. A new organizational construct should be sure to integrate these other intelligence products into near-real-time PED operations as they become available. The construct should also be able to extend naturally to fuller multi-INT operations in the future.

To realize these potential benefits, we propose a new area-centric organizational construct for conducting PED.

Rethinking Motion Imagery Processing, Exploitation, and Dissemination

The area-centric construct begins by redefining the elemental PED mission: Instead of providing PED for a platform, the objective becomes to conduct and coordinate PED across an area of operations. This is the main organizing principle. Such an area might be defined operationally as one in which the collection assets could realistically cross-cue one another or in which there is potential for coordinated collection in other ways, as with MTOs. When these areas

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[2] As noted earlier, automated target cueing will also be able to assist here when it is ready, as described in the companion report on PED tools and technologies.

are aligned with the areas of responsibility of supported units, this aspect of area-centric operations can be viewed as a form of multiunit alignment—an extension of the current DGS-SOF practice of aligning each PED crew with a single supported unit. Multiunit alignment can also serve as a transitional stage on the path to area-centric operations.

The other organizing principle of area-centric operations is to structure PED activity explicitly by time domain or analysis cycle: near-real-time processes (seconds or minutes), non–real-time processes (hours or days), and later analysis (weeks or months).[3] Although, in this report, we confine our attention to motion imagery exploitation, it is worth noting that these principles are more general. Grouping PED activity by area and time rather than by platform and INT is how we anticipate that the area-centric organizational construct would extend to multi-INT operations. The goal is simply to coordinate what can be coordinated and to separate what must be done now from what can be done later.

The distinction between near-real-time and non–real-time PED processes is a new aspect of this construct. Traditionally, all such PED would be considered simply "first look" or first phase. However, when, as with motion imagery, the PED process can be completed rapidly enough that PED analysts can become (and, indeed, we argue, should become) an integral part of the missions they support, PED becomes an interactive process driven by near-real-time interactions.

In the Air Force DCGS today, these near-real-time PED processes consist chiefly of chat room interactions between IAs, the MCE, and the supported unit. By contrast, non–real-time PED processes are the more-traditional PED processes that take longer to complete, such as exploiting IMINT collections from the Global Hawk or interpreting imagery produced by synthetic aperture radar. Also included in this category are PED processes that could, in principle, be completed in near real time but are instead set aside for later exploitation. At present, all motion imagery is exploited immediately as it arrives at the Air Force DCGS, but, as the growing scale of these collections compels the Air Force to be more selective in its application of PED resources, some less-critical motion imagery will inevitably be relegated to non–real-time analysis. We expect that such motion imagery would be digitally recorded (à la TiVo) and reviewed, for the most part, in fast-forward mode.

The final category of "later analysis" includes fusing, correlating, and sifting through older data to find new connections. These more-intricate forms of exploitation are conducted by many entities and are not the primary mission of the Air Force DCGS today. Whether they should be conducted by the Air Force DCGS analysis and reporting teams, as now is sometimes the case; exclusively by other agencies (e.g., the National Air and Space Intelligence Center); or collaboratively between them is a topic of ongoing discussion that we need not address here. It suffices to recognize that such analysis progresses at an altogether slower pace than either near-real-time or non–real-time PED and, as such, can be managed separately.

The Area Crew and the Analytical Pool

To implement these organizing principles, the area-centric construct establishes separate *area crews* to conduct and coordinate near-real-time PED for each area, and it has a combined *ana-*

[3] The terms *near real time* and *non–real time* are accurate but somewhat less than satisfying as a pair. Another suggestion has been to speak of *synchronous* and *asynchronous* PED, appropriating terminology from electronic communications.

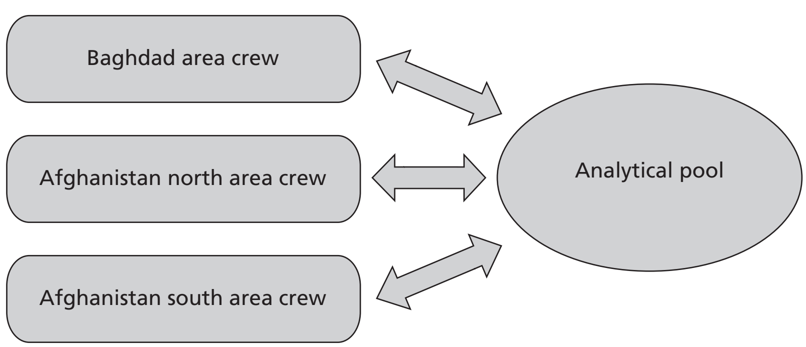
lytical pool to conduct non–real-time PED for all areas (see Figure 3.1). Broadly speaking, this division of labor parallels the way in which most commercial television production studios manage large projects.

The area crew is responsible for all interactions between Air Force DCGS personnel and other entities regarding the assigned area. Crew members maintain eyes on the motion imagery as required, communicate with the MCE and the supported unit, watch for self-cueing and cross-cueing opportunities between platforms operating in their area, and request retasking as appropriate. Extended experience with a particular geographic area should also enable crew members to acquire more local knowledge of that area and familiarize them with the particular reporting requirements of the associated combatant command (COCOM). In the context of reality television production, all the professionals we interviewed agreed that crew members with greater familiarity of the situation were able to log events more efficiently and recognize the importance of certain events more effectively. Studies of CCTV surveillance have also shown that situational awareness of the entire geographic area helps operators respond more rapidly to events on the screen.[4]

Unlike current motion imagery exploitation crews, area crews will vary in size. The size of an area crew at any given time should be driven by *mission needs* rather than by the number of platforms or the amount of motion imagery collected in that area. An illustrative scenario showing how this would work in practice is described later in this chapter. Like members of current motion imagery exploitation crews, all members of an area crew should continue to be colocated at the same DGS site. Although virtual collaboration tools are promising for many aspects of Air Force DCGS operations, they are not yet sufficiently rich and reliable to permit analysts to work together in near real time as effectively as they can face-to-face.[5] (Virtual collaboration technology is discussed in the companion report.)

The analytical pool is responsible for all other PED processes (i.e., those that need not, or cannot, be conducted in near real time). The pool would also provide surge capacity for the area crews so that a crew can be staffed up quickly as mission needs in that area demand. Members of the pool would generally provide relief for those on the higher-pressure real-time

Figure 3.1
Relationship Between the Area Crews and the Analytical Pool



RAND *TR1133-3.1*

[4] Keval and Sasse, 2010.

[5] Processes should, however, be standardized sufficiently to enable personnel to move between DGS sites without retraining.

area crews, allowing personnel rotation as needed.[6] Finally, as time permits, the analytical pool would also publish and maintain the multimedia database, as recommended in Chapter Two.

Analysts working in the combined pool would work much as they do today, save that they would no longer be associated with a particular platform, and they could be recalled to an area crew as conditions demand. The Air Force is already moving in this direction for some of its non–real-time PED. In particular, still imagery exploitation has already become largely *platform-agnostic* or *sensor-agnostic* in practice, meaning that analysts now follow the same procedures regardless of the source of the image, and most DGS sites also regularly pull analysts away from exploiting still imagery to exploit motion imagery when technical difficulties elsewhere force the site to take on additional motion imagery exploitation responsibilities. In this respect, the concept of an analytical pool can be seen as formalizing existing processes.[7]

Unlike area crews, analytical pools can be more easily distributed across DGS sites. Stringent requirements for the effectiveness of virtual collaboration tools can be relaxed for the analytical pool: Although analysts in the pool might need to collaborate, they do not need to do so in near real time. Although, in principle, the Air Force DCGS could establish a single analytical pool across all DGS sites, it would likely be more effective to keep separate analytical pools at each DGS site, dedicated to the areas served by the area crews at that site. Because we anticipate that analysts in the pool would be recalled to work on area crews from time to time, as mission needs dictate, this practice would help the analysts develop and maintain experience with the relevant target sets and COCOM requirements. It would also simplify local personnel management.

Processing, Exploitation, and Dissemination Crew Positions and Responsibilities

The area-centric organizational construct adds new responsibilities to the PED crews and, as such, entails a somewhat different slate of crew positions (see Table 3.1).

Currently, the IMS is responsible both for directing the operations of a standard motion imagery exploitation crew and for managing the personnel issues associated with that crew (e.g., rotation, shift changes). In the area-centric construct, in which PED crews can be larger and their operations more involved, these responsibilities must be split between two positions. The IMS-Operations (IMS-O) is at the forefront, responsible for conducting and coordinating near-real-time operations of an area crew; the IMS-Management (IMS-M) oversees the analytical pool and handles the back-of-the-house personnel management tasks that make performance of these tasks possible.

The IMS-O embodies the role of the director as described in Chapter Two. Because most of the new responsibilities in this construct fall to the IMS-O, this represents, in many ways, a new crew position. The IMS-O is charged with identifying self-cueing and cross-cueing oppor-

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6 This notion of surge capacity also parallels common practice in reality television production. When activity on set spikes, story producers working elsewhere in postproduction can be recalled quickly to the set to perform live logging or other functions.

7 The official CMSs for the Predator and Reaper, which require up to seven analysts (including supervisors) for motion imagery exploitation, are rarely, if ever, matched in practice. Many defend these numbers, however, because they afford the necessary surge capacity. We believe that formalizing this practice with an analytical pool would help the Air Force plan better for the right amount of PED surge capacity.

Table 3.1
Processing, Exploitation, and Dissemination Crew Positions in the Area-Centric Construct

Position	Air Force Specialty Code	Rank
MOC	Officer	Senior lieutenant, captain, major
IMS-O	1N17/9 (or officer)	Technical sergeant, master sergeant (or officer)
IMS-M	1N17/9 (or officer)	Technical sergeant, master sergeant (or officer)
IA	1N13	Airman, airman first class
TACOM	1N13/5	Senior airman, staff sergeant
Multisource analyst	1N13/5	Senior airman, staff sergeant

tunities between platforms operating in his or her area and with requesting potential retasking from the appropriate authorities.[8] In cases in which the Air Force DCGS may exercise a measure of tasking authority, as with MTOs, the IMS-O would manage retasking more directly.

The IMS-O is also responsible for performing the first cut of PED triage when required, nominating certain motion imagery collections for near-real-time exploitation while reserving others for later exploitation. By virtue of his or her bird's-eye view of near-real-time PED operations over the supported area, the IMS-O is uniquely well-situated to perform this task. The IMS-O would also be well-positioned to provide a form of overwatch for WAMI systems, looking for threats approaching from outside designated video chips, at such time as it becomes feasible to transmit the full WAMI image to the Air Force DCGS in near real time. Finally, the IMS-O must recognize when mission needs in the area have changed and request staff to be reassigned accordingly.

To perform these tasks effectively, the IMS-O must have broad situational understanding of the area he or she supports. The control room format is a useful tool for this; the COP display is all but essential. Note that there would be one control room and COP display for each supported area. (The control room need not be a physically separate room.) At current operational levels, most DGS sites would support only one area, but, as motion imagery collections become more prevalent in other types of operations around the world, this will change. This is one reason we emphasize that COP displays need not be large and that reconfigurable furniture arrangements for the control room are preferable.[9]

It is an open question whether the IMS-O position must be filled by an officer, unlike the current IMS position. We fully expect that current IMSs are quite capable of performing more-complex coordination tasks than their positions currently require, but we recognize that this must be confirmed in an experiment that simulates more-variable conditions than are commonly seen in the Air Force DCGS today. We can say, however, that the IMS-O should be a trained IMINT analyst and that he or she would benefit from being conversant with the capabilities of other INTs, although full cross-training is not required. Familiarity with SIGINT

8 Tasking responsibilities remain with the air and space operations centers and joint operations area collection managers.

9 Reality television control rooms are designed to be flexible for the same reason. Unlike the more-consistent levels of activity associated with broadcast news and sportscasting, activity in a reality television control room varies greatly over the course of a season. We believe that such variability better reflects Air Force needs.

capabilities in particular would help the IMS-O recognize some of the more-common cross-cueing opportunities and would pave the way for multi-INT operations down the line.

The IMS-M takes care of personnel and other management issues associated with shift changes and rotating and reassigning staff. These are similar to existing IMS duties with the exception that the analytical pool typically will be larger than today's standard motion imagery exploitation crew, and the IMS-M, of course, must also work with the new IMS-O position.

Because both IMS positions would be of the same rank and would report to the same MOC, cooperation between the IMS-Os and the IMS-M on the operations floor will be critical to the success of the overall operation. Although different reporting structures are possible, we recommend that most subordinate personnel, who will shift between the analytic pool and area crew as changing mission needs require, be initially assigned by the IMS-M to one of the area crews. The IMS-O would then release them back to the IMS-M when they are not needed and recall them as required.[10] This would enable the IMS-M to continue to manage all personnel functions while clarifying the supporting role of the IMS-M. Observations of interactions between producers and directors in the television industry suggest that the effectiveness of such interactions could depend considerably on the temperaments of those involved. We expect that Air Force leadership training will assist these supervisors in reaching an equable arrangement.[11]

The subordinate crew positions are the IA, the TACOM, and the MSA. Under the area-centric construct, the IAs perform the same tasks as they do now, keeping eyes on a motion imagery spot and reporting on the events that transpire—by speaking aloud to another analyst. There is, however, a minor difference in the reporting process. Currently, one IA maintains eyes on while another communicates via chat. Sometimes, other crew members also participate in the chat discussion.[12] However, in the future, when several motion imagery streams collected in the area might support the same mission, or when one WAMI image might support several missions, there is a higher potential for confusion regarding the lines of communication between the area crews and the supported units. For this reason, we recommend a clearer assignment of communication responsibilities.

In this construct, communications between the area crew and supported unit are the sole responsibility of the TACOM. More precisely, the job of the TACOM in area-centric operations is to act as the single point of contact for all communications between the area crew and *one* supported unit. (An area crew that supports multiple units will require multiple TACOMs.) The TACOM will ensure that the near-real-time intelligence provided by the IAs is passed down to the supported unit and that the supported unit's requirements are passed up to the IMS-O. Even when the crew supports only one unit, establishing a policy of having a single point of contact will head off potential confusion in the future.[13]

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[10] We are indebted to Larry Hanser for this suggestion.

[11] It might be valuable for future IMS-Os and IMS-Ms to visit a working television control room. Beale AFB is not all that far from Hollywood, and the learning could run in both directions.

[12] Sometimes, communication is also the responsibility of the TACOM alone. The respective responsibilities of the IA and TACOM in this regard are not always clear and have yet to be fully standardized throughout the Air Force DCGS.

[13] In Chapter Two, we raised the possibility that shifting to spoken communications (radio) might allow one IA to handle both observation and communications. Likewise, even without a shift to radio, the IA might be able to do so if the supported mission is sufficiently low in urgency and sufficiently slow in operational tempo that the strict eyes-on requirement can be lifted. (Headsets with speech-to-text could assist here as well.) However, given the potential for confusion in the chatter, the Air Force should consider combining the IA and TACOM positions only in areas where there is still (as is usually the case today) a one-to-one correspondence between motion imagery streams and supported units.

To provide continuity and ease of communications, wherever possible, the same TACOM should be assigned to interact with the same supported unit, as is the practice for the screeners at the 11th IS PED crews that support specific SOF teams.[14] A trained TACOM familiar with both the area and the supported unit (as well as the reporting requirements of the relevant COCOM) can more easily render a tailored report of the situation as it progresses, translating the blow-by-blow descriptions of one or more IAs into a more coherent narrative for the supported unit.[15]

The last position, the MSA, is responsible for integrating non–real-time intelligence products from the analytical pool into near-real-time PED operations. Although the MSA is a new addition to the conventional PED crew, it is already standard for the 11th IS. Because an area crew focuses only on near-real-time PED interactions, it will be important to have a member of the crew who can trawl through all relevant databases from the non–real-time PED processes (e.g., still imagery libraries) to incorporate the relevant intelligence products into the real-time PED operations.

Although the MSA will draw on other INTs, this should not be confused with true multi-INT analysis: The MSA is not expected to generate formal fused intelligence products. Rather, the role of the MSA is to bring intelligence from other INTs to the table—to pull the information from the products of the analytical pool and to communicate with the analytical pool to help it push relevant products forward. Until context-based software programs are able to perform this function reliably, a human conduit who can work in both directions is essential.

Finally, we should point out that one current PED crew position is *not* found in the new area crew: the IRE. As we have indicated, the crucial intelligence products of near-real-time PED are not the final annotated imagery reports but the near-real-time interactions between the PED crew, the MCE, and the supported unit that gives rise to them. These interactions are documented in the chat transcript and the recorded motion imagery. If the Air Force DCGS commits to building and maintaining a searchable multimedia database with automatic linking of chat transcripts to the associated motion imagery, as is recommended in Chapter Two, then this database itself *becomes* a primary intelligence product. All essential information will be available almost immediately via the database, reducing further the urgency of writing up the final incident report. To the extent that these reports are still required, they should be handled in non–real time by the analytical pool, freeing the area crew to concentrate on near-real-time PED operations.

Implementing Area-Centric Operations: An Illustrative Scenario

The best way to visualize area-centric operations is to walk through an example of how it might work in practice. Because near-real-time PED operations are the focus of the area-centric construct, it is important to understand how a scenario might unfold over time. To this end, we

[14] At DGS-SOF, the screeners typically also enjoy firsthand knowledge of the unit they support through forward deployment at some point in their careers.

[15] Adopting a standard lexicon for text-based communications, as recommended in Chapter Two, would also help.

constructed an illustrative urban operations scenario based (loosely) on certain operations that occurred in an area near Baghdad in 2006.[16]

Although the full area of operations is Baghdad, for the sake of brevity, we focus on a neighborhood of particularly intense activity, to which we refer as the ISR focus area. The staffing figures in this section reflect only the analysts associated with the activity in the smaller area, not the entire area crew, which is presumably larger.

The scenario covers 24 hours and involves three CAPs: *Reaper 1*, equipped with the standard MTS payload; *Reaper 2*, equipped with MTS and Gorgon Stare; and a *Global Hawk* equipped with ground moving target indicator (GMTI) capability. (For convenience, we speak of these CAPs as though they were maintained by a single platform in continuous operation, glossing over the fact that a CAP actually represents multiple platforms that must replace one another when their endurance is exhausted.) Reaper 1 supports the ISR focus area for the entire 24-hour period. Reaper 2 is assumed in this scenario to support operations for eight hours.[17] The Global Hawk will be in the vicinity for 12 hours, but only its GMTI capability is used to support operations in the ISR focus area. Global Hawk is a high-altitude platform, and its other capabilities could support operations elsewhere.

The plan for the day consists of four missions: A patrol base will be established in the northwest corner of the area, two roads will be cleared of any IEDs that might be there, and the Global Hawk will use GMTI to surveil the area around the river for illegal crossings. The map is shown in Figure 3.2. Some unplanned, ad hoc missions will also arise over the course of the day, enabled by the comparative wealth of available collection assets and the area-centric construct. We note the staffing changes associated with these missions and conclude with an overview showing the staffing levels of the area crew over time.

Sequence of Events

The key events of this 24-hour period are summarized in Table 3.2 and described in detail in this section.

The day begins as Reaper 1 arrives on station. The Reaper takes up its CAP at 0000 local time to provide indications and warnings in preparation for the scheduled operation. At this point, the area crew consists of an IA to monitor the motion imagery from the Reaper, a TACOM to communicate with the supported unit, an MSA, and the IMS-O. Because the IMS position is split in this construct, we include the IMS-M in the count as well, bringing the total to five.

At 0400, the Global Hawk begins GMTI surveillance of the river area, and the IMS-O asks for another IA to join the crew to monitor the information.[18] Note that this IA is not the primary exploiter of the GMTI data but rather is tasked to keep abreast of information coming from the Global Hawk regarding the river and ensure that this reaches the area crew.

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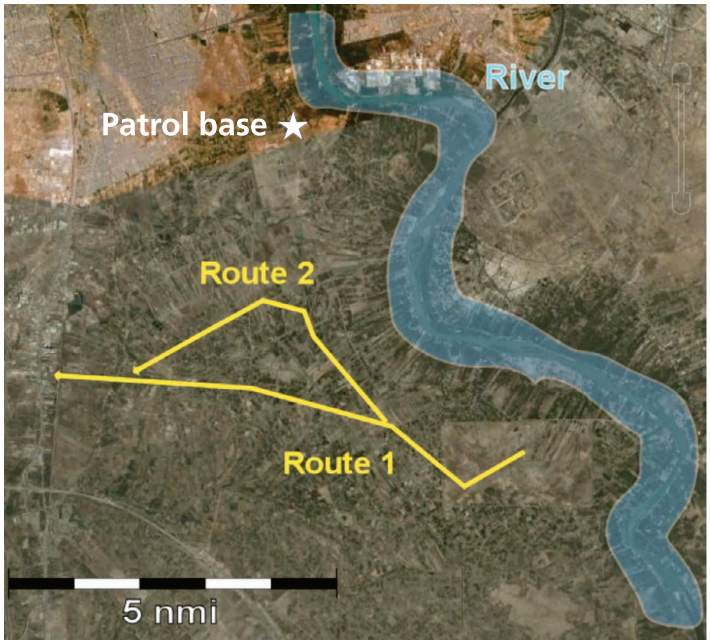
[16] Matthew E. Boyer, *Ground Tactical Integration of CFACC ISR and Close Air Support in Irregular Warfare*, Santa Monica, Calif.: RAND Corporation, draft report, March 2010, not available to the general public. The actual events are not depicted but were used to provide timing and spacing consistent with actual experience. We intensified the activity and provided additional ISR assets (e.g., Gorgon Stare) that were not available at the time.

[17] In this scenario, we implicitly assume sufficient bandwidth to transmit the full set of motion imagery from the Gorgon Stare sensor package (a WAMI system) to the DCGS. Although this is not yet considered feasible, we believe that the Air Force should plan for this eventuality and adopt an organizational construct for PED capable of exploiting WAMI.

[18] We assume that the Air Force DCGS can access this information.

Figure 3.2
Scenario Intelligence, Surveillance, and Reconnaissance Focus Area



NOTE: nmi = nautical mile.
RAND *TR1133-3.2*

Table 3.2
Sequence of Events and Missions

Event or Mission	Time
1. Reaper 1 CAP	0000–2359
2. Global Hawk GMTI surveillance	0400–1600
3. Patrol base established	0600–0700
4. Gorgon Stare orbit 1	1000–1200
5. Gorgon Stare orbit 2	1200–1400
6a. River patrol (investigate GMTI)	1300–1400
6b. Reaper 1 supports river patrol	1300–1400
7. Gorgon Stare orbit 3	1400–1600
8. Gorgon Stare orbit 4	1600–1800
9. Mortar fire and local patrols	1630–1730
10. Route clearance complete	1800

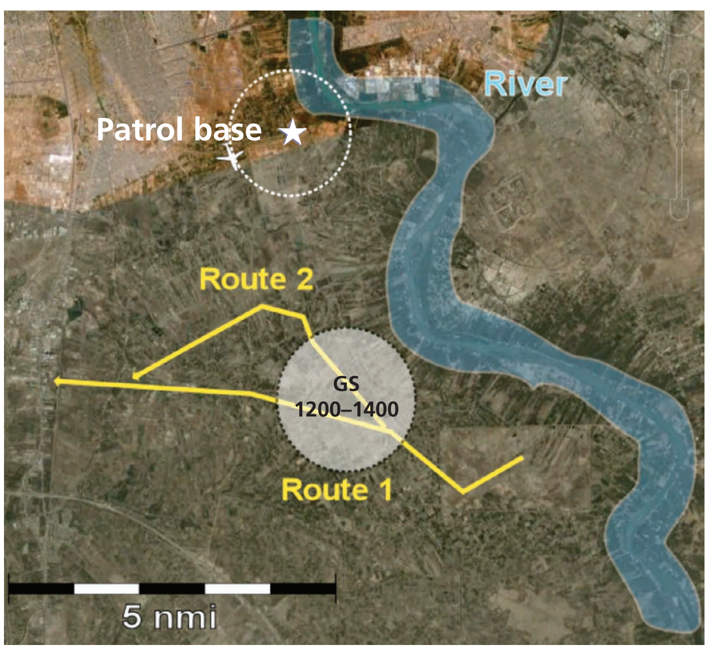
Coalition forces move in to establish the patrol base near dawn (0600 to 0700), and the Reaper now provides close air support. In recognition of this shift of mission, an IA is brought onto the crew for this hour in anticipation of a possible ambush. The IA will need time to build situational awareness in the event that the mission involves troops in contact. However, in this scenario, the patrol base is established successfully without incident, so the IA returns afterward to the analytical pool and the Reaper returns to its previous mission.

IED route clearance begins mid-morning. At 1000, Reaper 2 takes up its first position and the first team begins to clear the first route. After two hours, the aircraft orbit shifts two miles to the west and the Gorgon Stare sensor package is now in a position to watch both routes. As each route clearance commences, another two analysts (one IA and one TACOM) are added to watch the video chips associated with those routes. Meanwhile, the IMS-O keeps an eye on the full Gorgon Stare image, looking outside the selected video chips for impending threats.

Figure 3.3 shows the situation as it stands halfway through the day at 1200. Reaper 1 is shown near the top of the map circling the patrol base (represented as a star). The approximate coverage area provided by the Gorgon Stare sensor package on Reaper 2 during 1200–1400 is shown as the disc labeled "GS." At this point in time, the area crew includes four IAs, three TACOMs, the MSA, and the IMS-O. (We continue to count the IMS-M as well, bringing the total to ten.)

ISR activity in the area is already high when the first unplanned event occurs. At 1300, the GMTI detects a vehicle moving into the neighborhood of the river. At this point, the ground commander must make a decision about how to investigate the GMTI hit. In this scenario, the commander decides to send a patrol. The IMS-O is able to suggest that a temporary

Figure 3.3
Scenario at 1200



NOTE: GS indicates the Gorgon Stare coverage area from Reaper 2.
RAND *TR1133-3.3*

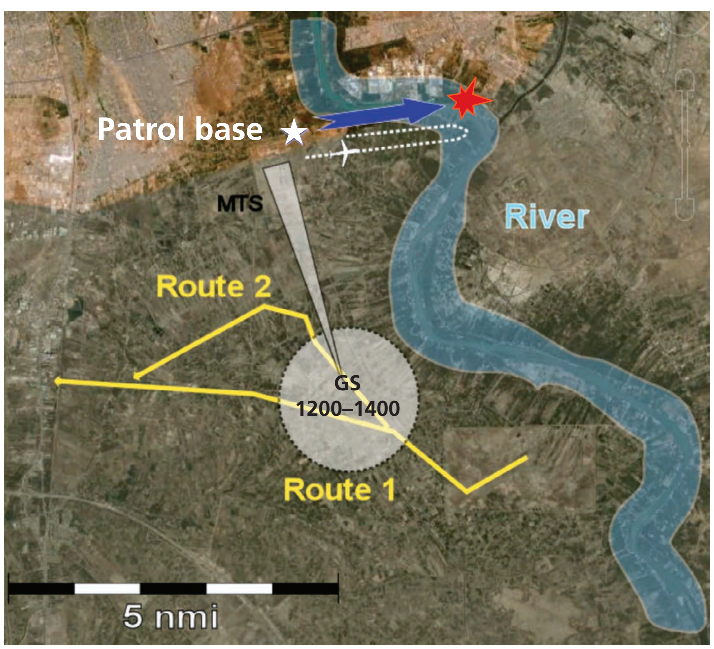
realignment of assets would enable the commander to send out a patrol with additional PED support. The IMS-O is in a unique position to recognize this possibility because of his or her broad situational awareness of the area.

The realignment of collection assets is shown in Figure 3.4. Reaper 1 diverts temporarily from its CAP to follow a patrol along the river to investigate the possible GMTI incident. Meanwhile, the MTS on the Reaper 2 is used temporarily to continue watching the new base. Another IA and TACOM are added to the crew to support the new operation, while the same IAs who were watching the FMV from the MTS on Reaper 1 now follow the same scene on Reaper 2. Because the PED is conducted in an area-centric manner, the IMS-O can ensure that the *same* IAs keep watch over the motion imagery of the patrol base, even though this imagery is now temporarily supplied by the other Reaper. This continuity of PED support allows commanders to retask assets with minimal disruption.

After the GMTI hit is investigated (we assume that no further ISR assets are involved in the investigation), the situation returns briefly to the previous state. Reaper 1 returns to its orbit around the patrol base, and Reaper 2 continues to provide overwatch to both route clearance teams, occasionally shifting westward as needed. At 1600, the Global Hawk leaves station, concluding the day's river surveillance, and the IA formerly assigned to that task is returned to the analytical pool.

The final unplanned sequence of events is initiated at 1630, when one of the ground units reports mortar fire. The TACOM informs the IMS-O, who then directs the MSA to pore through recent Gorgon Stare footage to look for the telltale flash of the mortar launcher.

Figure 3.4
Patrol Sent to Investigate Possible Ground Moving Target Indicator Hit and Intelligence, Surveillance, and Reconnaissance Support Provided



NOTE: The blue arrow indicates the patrol. The red indicates the possible GMTI hit.
RAND *TR1133-3.4*

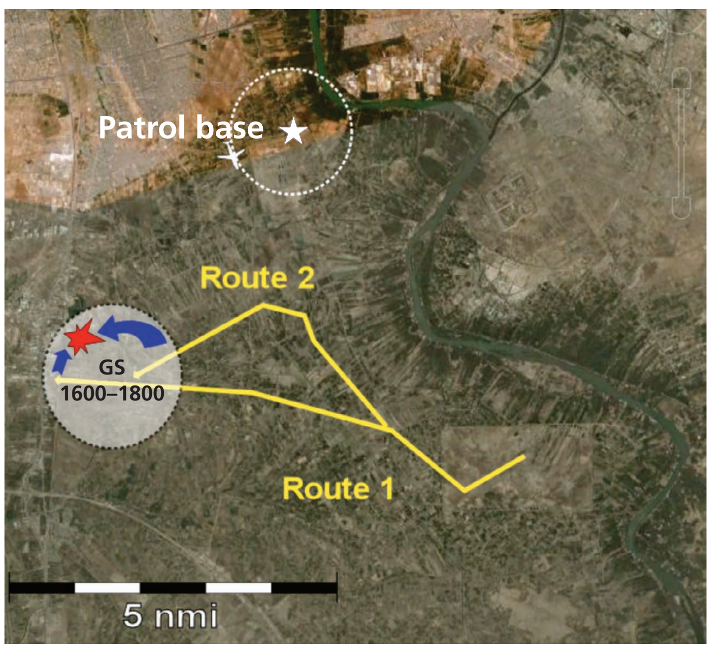
An additional IA is called in to assist the MSA in this task. In this scenario, the Gorgon Stare video archive search is successful and the source of the mortar fire is located. The ground commander then dispatches two patrols to converge on the site from opposite directions, as shown in Figure 3.5. The IMS-O is able to meet the commander's requirement to provide PED support by requesting the IMS-M to release four more crew members (two IAs and two TACOMs) from the analytical pool to watch the extra Gorgon Stare video chips and communicate with the respective patrol units.

At the end of the day, after the patrols have successfully completed their missions and the routes have been cleared of IEDs, all of the additional members of the PED area crew added during the day return to the analytical pool, leaving the original core crew of five.

Processing, Exploitation, and Dissemination Staffing

The staffing of the area crew over the course of the scenario is shown in Figure 3.6. In the area-centric construct, the staffing level of each PED area crew changes over time to meet the varying needs of planned and unplanned missions in that area. The most prominent spike in staffing represents the surge in demand associated with the response to the mortar fire report. This variability is in contrast to the platform-centric staffing approach, which would change only when the second Reaper (with Gorgon Stare) is present.[19]

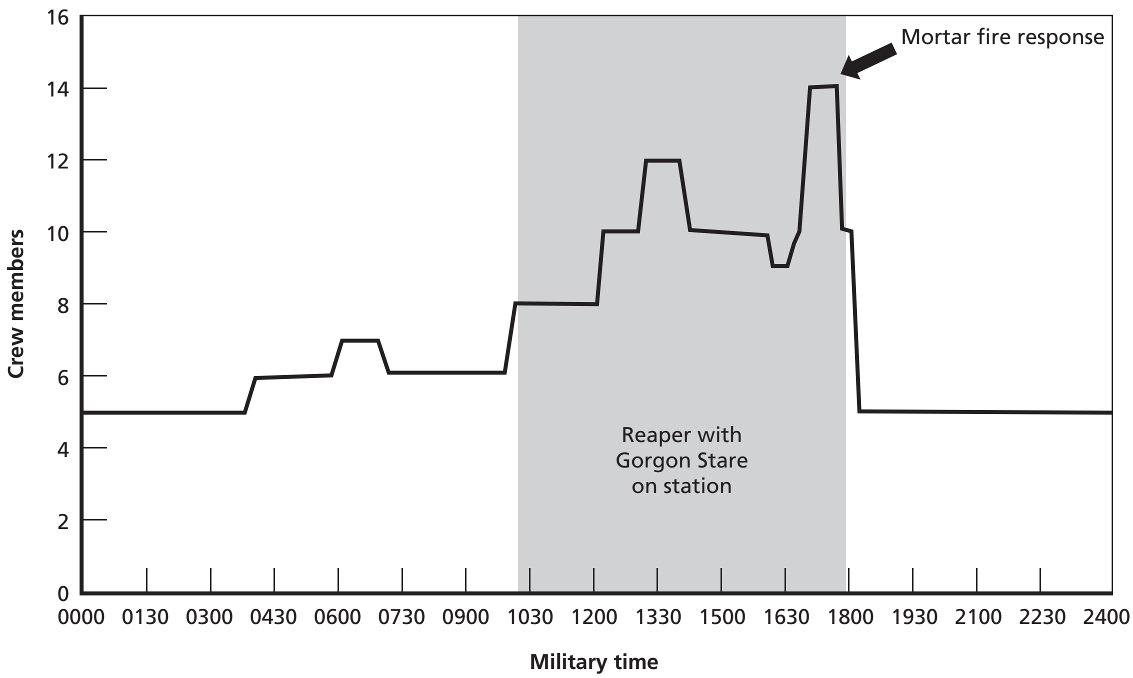
Figure 3.5
Local Patrols Converge on Source of Mortar Fire



NOTE: The blue arrow indicates the patrol. The red indicates the source of mortar fire.
RAND *TR1133-3.5*

[19] Although there is no established practice for providing PED for the Gorgon Stare sensor package under the current construct, the latest available draft version of Air Combat Command's enabling concept for Gorgon Stare at the time of this writing (Air Combat Command, 2010) does indeed propose a fixed crew size for each platform.

Figure 3.6
Area Crew Staffing over Time



RAND *TR1133-3.6*

In this figure, we have not allocated personnel for premission and postmission briefs at the beginning and end of the day because the PED mission is no longer tied to a particular sortie but supports the area on an ongoing basis. Of course, daily mission briefings, or mission briefings for each shift, will still be required; we expect that these would be prepared either by a DCGS analysis and reporting team (DART), which is often the case now, or by the analytical pool in consultation with the MSAs and IMS-Os.

Conclusion

The scenario described in the previous section illustrates how the staffing of one particular area crew might vary over the course of a day. But the overall staffing level at each DGS site would be more stable. The analysts who join the area crew throughout the day do not materialize on the operations floor: They must already be on duty in the analytical pool. The area-centric construct does, however, allow those personnel to work more efficiently, joining the near-real-time PED operations of the area crew only as mission needs dictate, then returning to the analytical pool to perform non–real-time PED functions and other duties. The area-wide scope also allows the same personnel to provide PED for the same content, even when the motion imagery collection asset changes.

Given technological trends, we have every reason to expect that the amount of motion imagery arriving at the DCGS will, at some point, become so great that the Air Force will have no choice but to apply its PED resources selectively—in other words, regardless of the organizational construct employed, maintaining maximum possible surge capacity at all times will

no longer be feasible and the Air Force will have to confront the thorny problem of determining what constitutes a *reasonable* surge capacity for PED. Because the area-centric construct ties area crew staffing to mission needs, defining PED staffing requirements for each type of supported mission would be the first step in determining what a reasonable surge capacity for PED might be.[20]

In the years to come, the prevailing conditions in the ISR information economy will change from scarcity to plenty: Instead of rationing its limited supply of collection assets, the Air Force will face the task of providing PED to mine the nearly limitless data collected. The area-centric construct is a way to begin to organize the Air Force DCGS now to prepare to meet this future.

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[20] The analysis required to establish PED requirements for each type of supported mission unfortunately goes beyond the scope of this report. Here, we deal with PED in the context of current operations only; future missions will entail different PED requirements. In particular, some less time-critical missions could be managed in serial rather than in parallel, reducing the overall demand for personnel. Sizing PED requirements for all relevant missions is an important area for further research and experimentation.

CHAPTER FOUR

Conclusion: Lessons from the Commercial World

The rapid rise in motion imagery collections, and the advent of new WAMI systems, presents a significant challenge for Air Force PED. Yet, if properly managed, these new capabilities also offer the opportunity to achieve more-coordinated, more-agile PED operations than ever before. In this report, we examine the parallels between Air Force motion imagery exploitation and practices in the commercial world to look for insights that could help the Air Force achieve this goal. We arrived at a handful of broader lessons and specific recommendations.

Lessons from Closed-Circuit Television Surveillance

Studies of CCTV surveillance offer a cautionary lesson for the Air Force DCGS. Although CCTV surveillance operations regularly assign operators to observe many motion imagery streams at once—often more than a dozen at a time—this practice is driven by a trade between quality and quantity that the Air Force cannot afford to make in current operations. When troops are in contact with the enemy, significant "miss rates" are unacceptable. The literature associated with CCTV is clear: For current operations, assigning IAs to watch multiple motion imagery spots risks a significant adverse impact on performance.

For this reason, we believe that the Air Force DCGS policy of maintaining eyes on each motion imagery spot remains appropriate. However, there are at least three individuals (or groups of individuals) in a position to watch the motion imagery as it comes in: the IAs at the Air Force DCGS, the sensor operators at the ground control station, and the intelligence analysts in the supported unit who receive the raw motion imagery over the Remote Optical Video Enhanced Receiver terminal.

Although the latter two positions entail other responsibilities that would preclude either of them from keeping eyes on the motion imagery at all times, working together, they might be able to do so effectively when the PED mission is not time-sensitive and when there is no potential for coordination with other PED operations. These circumstances are rare in current operations but could become more common in the future as motion imagery collections continue to grow and they are used to support less time-sensitive missions. Further study is needed to determine when and whether this is the case.

Emerging technologies to process and exploit motion imagery might also enable the Air Force to relax its eyes-on requirement, although appropriate tools are not yet available. Most promising are automated tools that can analyze incoming motion imagery and cue human analysts to inspect segments that might depict prescribed objects or activities of interest. These technologies are discussed in the companion report.

Lessons from Reality Television Production

Our investigation of reality television production revealed many points of correspondence with Air Force motion imagery PED. Although the contexts of these operations are certainly extremely different, nevertheless both of them exploit multiple streams of motion imagery in near real time, both of them operate 24/7 for extended periods, and both of them dynamically retask and cross-cue sensors. Their respective crew structures also show some remarkable parallels. However, several key organizational features and management practices are absent from Air Force motion imagery PED.

Firstly, nearly all television production crews—not just those working in the reality television genre—make use of the same control room format. Even live broadcast operations, such as sportscasting, do this. The distinguishing feature of this format is the aggregated video and data display on the main wall toward which all workstations are oriented. The prevalence of this format across operations of all sizes and budgets attests to its versatility; we also observed firsthand its robustness in response to changes in operational tempo.

Secondly, all reality television production crews also make extensive use of multimedia databases (or *digital asset management*). These tools link live logs of the motion imagery, compiled in near real time, with the motion imagery and store it all in an accessible and searchable format. Maintaining and building this database is an important crew responsibility because it greatly facilitates later analysis in postproduction. Existing commercial tools can effectively manage at least a few months' worth of motion imagery from a dozen or more cameras; more-advanced tools are also under development. The Air Force has begun to recognize this need; the companion document discusses such tools in much greater detail.

Thirdly, all near-real-time communications among television production crews are spoken, by means of radios and microphone-enabled headsets, as opposed to the text-based chat room communication practices of Air Force PED crews. Spoken communication allows supervisors to be mobile, walking around the operations floor to better direct crew activity. It also enables crew members to multitask, communicating what they observe without taking their eyes off the screen. The potential for undesirable cross-chatter is real, however; disciplined communications are of value in any medium.

Finally, a wider view of commercial television production indicates a common organizational construct for large-scale collection and management of motion imagery. For near-real-time operations, all motion imagery collected from one area is managed together by one crew, while that acquired from different areas is managed by different crews. It is only for later analysis that motion imagery from all locations is brought together. This permits crew members to focus on near-real-time operations and provides them with context that can assist them in their analysis.

Recommendations

From our investigations of commercial practices and Air Force DCGS operations, we make the following recommendations:

- *Air Force motion imagery exploitation crews should adopt the control room format*. This part of the operations floor should have a COP display to give a bird's-eye view for overall

situational understanding of all related motion imagery. When possible, it should also display SIGINT and GMTI collection information, Blue Force Tracker, and any other geolocated intelligence that can provide context. Although, in current operations, DGS sites are typically tasked to exploit a handful of motion imagery spots, from widely separated areas, we expect that, in the future, the increase in CAPs and the introduction of WAMI will lead DGS sites to exploit numerous motion imagery spots covering nearby areas (either from the same or from different platforms), thereby opening up the potential for many more cross-cueing opportunities.

- *Air Force motion imagery exploitation crews should build and maintain a tagged, searchable motion imagery database.* Some Air Force DCGS sites have begun to use these; we recommend approaching this from an enterprise-wide perspective to avoid potential interoperability issues. Creating such a database will allow analysts from the Air Force and other agencies to mine through the volumes of video data to glean additional intelligence. The Air Force might want to consider the feasibility of adapting commercial products to this task.
- *The Air Force should streamline some of its communication practices within Air Force DCGS and between the Air Force DCGS and other partners.* Within Air Force DCGS, providing IAs the option of using headsets with speech-to-text capabilities could allow them to participate in existing chat rooms with less distraction. The Air Force DCGS should move toward a single-point-of-contact approach when it comes to communications with supported units, when one PED crew supports multiple units or when multiple PED crews support the same unit. Finally, a common lexicon for text-based communication would be a valuable addition to Air Force DCGS practices.
- *The Air Force should move to adopt a new, area-centric organizational construct for motion imagery PED.* This proposed organizational construct reframes the Air Force PED mission, shifting the focus from conducting PED separately for each platform to coordinating PED for all platforms in an area of operations. The area-centric construct is designed to capitalize on cross-cueing opportunities and to assist PED crews in supporting multiple units. It scales PED staffing with mission needs rather than number of collectors, focusing on output rather than input to the PED process. It also provides for a PED triage mechanism to allow the Air Force to apply its resources selectively as the need arises. Finally, it offers a path toward multi-INT operations. Inclusion in an exercise would be an appropriate first step to assess this construct.

These recommendations stand independently of one another. The first three are intended to address the needs of current and near-term operations, so we recommend that they be implemented as soon as possible. They might also facilitate the move to more multi-INT operations in the medium term. The final recommendation is meant to prepare the Air Force DCGS to meet the longer-term challenges of future ISR capabilities and entails a larger change in operations.

At present, with only a handful of motion imagery streams currently exploited at each DGS site, and with WAMI systems only beginning to be deployed, area-centric operations will not look much different from current operations when first adopted. Furniture can be rearranged, headsets can be provided, a COP display can be assembled, digital asset management tools can be acquired, and supervisors can be trained to look for coordination and cross-cueing opportunities—but, for now, the effects that these changes have on current operations will be

modest. Multiunit alignment could also serve a useful transitional stage in the change from platform-centric to area-centric operations.

More work is needed to develop the area-centric construct further to encompass full multi-INT operations. Moreover, in this report, we have concentrated on the PED requirements for persistent surveillance and overwatch, the two most prominent missions making use of motion imagery in current operations, but less time-sensitive missions, such as the more generic intelligence-gathering missions that could become more prominent after the conclusion of current operations, will entail different PED requirements and could require somewhat different crew skills. Consideration should also be given to extending the area-centric construct beyond Air Force DCGS to include the MCE, integrated ISR tasking processes, and motion imagery from manned collection assets, such as Project Liberty.

The area-centric operational construct treats Air Force PED as an integral part of joint ISR operations rather than as a commodity provided to others. It is first and foremost a way forward to prepare the Air Force DCGS to deliver future ISR capabilities; it provides a framework into which the Air Force DCGS can grow.

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